Proposed Residential Development
Torridon House Car Park, Westminster

Ground Investigation Report

On behalf of: **City of Westminster**

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Summary

This Ground Investigation Report presents an assessment of the ground conditions together with suggested characteristic values of geotechnical parameters for use in the design of the geotechnical elements for the proposed development at Torridon House Car Park, Westminster.

SITE DESCRIPTION The Site is situated on the gently undulating ground adjacent to the former Westbourne river. Natural ground levels in the vicinity of the Site are between about 32 and 33 m above Ordnance Datum (OD) with a gentle fall to the northwest of about 1 vertical in 200 horizontal.

Historically the Site was undeveloped agricultural land to the south of the historical hamlet of Kilburn up to the early-1860s when the Site was developed with terraced properties fronting onto Andover Place. During World War II a number of buildings to the northwest of the Site were damaged beyond repair by bomb strikes whilst the adjacent buildings on the Site suffered general blast damage. By the late-1960s, the Site had been redeveloped as a car park associated with the adjacent Torridon House development.

GROUND CONDITIONS The ground conditions in the area of the Site comprise Made Ground overlying the London Clay Formation. Based on the ground investigation information, the ground conditions on the Site are summarised in the following table.

Summary of Ground Conditions

Formation	Top of Stratum, m bgl[1] (m OD)	Thickness, m	Description
Made Ground	Ground Level	0.5 to 1.5	Surface pavement of asphalt overlying thick beds (0.25 to 0.6 m) of intermixed SAND and GRAVEL of brick, concrete and clinker, locally containing thin beds (0.05 to 0.1 m) of concrete and asphalt. Generally underlain by firm brown slightly sandy CLAY with some gravel of brick, concrete and asphalt.
London Clay	0.5 to 1.5 (30.6 to 32.0)	~45.0	Firm brown CLAY grading with increasing depth to stiff and very stiff grey fissured CLAY.

Note: (1) denotes below ground level

Groundwater levels on the Site are typically close to ground level, however, the expected low permeability of the soils on the Site is likely to limit inflows into open excavations during construction.

GEOENVIRONMENTAL CONDITIONS Measured concentrations of potential contaminants in the soils on the Site are typically below the assessment values appropriate for a residential with home grown produce land use. The exceptions comprise slightly elevated concentrations of heavy metals and speciated PAH within samples of the Made Ground. In addition asbestos containing material was identified in 1 of 16 soil samples screened prior to chemical analysis.

It is expected that the proposed buildings and hard surfaces, together with a layer of clean soil cover to the proposed areas of soft landscaping will be sufficient to ensure the potential risk to future site users associated with contaminated material is very low.

It is expected that any Made Ground to be disposed of off-site may, in general, be classified as non-hazardous waste. The natural soils on the Site are not likely to contain significant concentrations of contaminants and may be classified as inert.

An assessment of the measured concentrations of ground gases indicates the Site may be classified as Characteristic Situation 1 in accordance with the criteria given in BS 8485 (2015). For Characteristic Situation 1, BS 8485 (2015) advise that gas protection measures are not required.

GEOTECHNICAL CONSIDERATIONS The proposed development comprises the construction of a two blocks of three and five storeys residential units. The principal geotechnical considerations are the strength and compressibility of the founding soils and hence, the foundation requirements for the proposed structures.

SPREAD FOUNDATIONS For the ground conditions present at the Site, shallow pad or strip footings founded within the undisturbed London Clay Formation may be an appropriate option for founding the proposed town houses. A presumed bearing value not exceeding 80 kPa is recommended for preliminary determinations of the required dimensions of pad and strip footings. The near-surface soils are shrinkable typically having a high volume change potential and due allowance should be made in the design of foundations for the past, present or future presence of the trees adjacent to the proposed development.

PILE FOUNDATIONS For the ground conditions present at the Site, bored and cast-in-place piles formed using conventional rotary auger techniques or continuous flight auger techniques are appropriate for the proposed apartment blocks. Preliminary estimates of the working capacity of 350, 450 and 600 mm uniform diameter bored piles are given in the report.

FLOOR SLABS In general, floor slabs supported on a suitable thickness of sub-base will prove adequate. The exceptions are any slabs in areas where the depth of Made Ground below the sub-base exceeds 600 mm and areas within the zone of influence of trees which are to remain or be removed; in these areas the proposed buildings will require suspended floor slabs.

PAVEMENT DESIGN Pavements carried on a suitable depth of capping/sub-base should prove adequate and a CBR value of 2.5 per cent for the near surface soils is recommended for pavement design.

BURIED CONCRETE It is recommended that concrete in contact with the ground is designed for Design Sulphate Class DS-4 and ACEC Class AC-3s as defined by BRE (2005).

The summary contains an overview of the key findings and conclusions. However no reliance should be placed on any part of the summary until the whole of the report has been read.

1.0 Introduction

1.1 Preamble

1.1.1 Peter Brett Associates LLP (PBA) has been commissioned by the City of Westminster (the Client) to prepare a Ground Investigation Report for the proposed residential development at Torridon House Car Park, Westminster.

1.2 Background

1.2.1 Previously a desk study review of readily available published information was carried out to assess the ground conditions on the Site and the potential for contamination to be present associated with previous and present uses of the Site and the surrounding areas. Thereby to enable a Tier 1 qualitative assessment of the ground stability and geoenvironmental constraints to be made to inform the preliminary design of the proposed development. The findings of the study are presented in a separate Phase 1 Ground Condition Assessment prepared by Peter Brett Associates LLP (PBA, 2019) acting on behalf of the Client.

1.2.2 Subsequently, an intrusive ground investigation was carried out in the area of the Site to provide information on the ground conditions, including the concentrations of potential contaminants, to inform the design of retaining walls, foundations and other geotechnical elements for the proposed redevelopment. The factual results of the investigation are presented in separate report prepared by Concept Engineering Consultants Limited (CEC, 2019) acting on behalf of the Client. The fieldwork and laboratory testing were carried out under the technical direction of PBA.

1.3 Scope of Work

1.3.1 The scope of work performed by PBA comprises the preparation of a Ground Investigation Report in general accordance with the requirements of BS EN 1997-2 (2007).

1.3.2 This Ground Investigation Report presents an assessment of the ground conditions, together with recommended characteristic values of geotechnical properties for use in the design of the geotechnical elements of the proposed redevelopment. The report also presents comments on the ground conditions in relation to the design and construction of the geotechnical elements of the proposed redevelopment. In addition, the report presents an assessment of the risks associated with any existing contamination in the ground to human health, the environment and the proposed structures such that likely mitigation measures or remedial works can be determined appropriate for the proposed redevelopment of the Site.

1.4 Limitations

1.4.1 Unless stated otherwise, information from the desk study and factual ground investigation report has not been included in this report and, where referenced, the reports presenting this information should be read in conjunction with this report. Guidance on the context of this report and any general limitations or constraints on its content and usage are given in a separate guidance note included after the text of this report.

2.0 The Site

2.1 Site Location

2.1.1 The Site is centred at National Grid Reference TQ 256 832 about 0.6 km southeast of the historical village of Kilburn. The location of the Site is shown on a Site Location Plan presented as **Figure 1**.

2.1.2 The Site is rectangular in plan with overall dimensions of about 25 by 35 m. The Site is bounded by Andover Place to the northeast, residential properties to the southeast, Torridon House to the southwest and Kilburn Park Road and a primary school to the northwest. The layout of the Site is shown on a Site Layout Plan presented as **Figure 2**.

2.1.3 The Site is situated on the gently undulating ground adjacent to the former Westbourne river which formerly flowed southwest about 125 m northwest of the Site. Natural ground levels in the vicinity of the Site are between about 32.0 and 33.0 m OD with a gentle fall to the northwest of about 1 vertical in 200 horizontal.

2.2 Historical and Current Site Use

Site History

2.2.1 Historically the Site was undeveloped agricultural land to the south of the historical hamlet of Kilburn up to the early-1860s when the Site was developed with terraced properties fronting onto Andover Place. During World War II a number of buildings to the northwest of the Site were damaged beyond repair by bomb strikes whilst the adjacent buildings on the Site suffered general blast damage. By the late-1960s, the Site had been redeveloped as a car park associated with the adjacent Torridon House development.

2.2.2 A detailed site history and copies of historical mapping are included in the Phase 1 Ground Condition Assessment (PBA, 2019)

Current Site Use

2.2.3 The Site is currently occupied by the Torridon House car park comprising an at-grade car park with provision for off street parking. Access to the car park is through a gated entrances on Andover Place and Kilburn Park Road. A series of lockup stores are located along the southeast and northeast boundaries of the Site. An electrical substation is present on the western part of the Site.

2.2.4 The layout of the Site is shown on the Site Layout Plan presented as **Figure 2**.

2.3 Geology

2.3.1 The 1:50 000 scale geological sheet of the area (BGS, 2006) and the geological memoir (BGS, 2004), indicate that the Site is underlain by the London Clay Formation with the Lambeth Group present at depth. In addition, it is expected that the natural strata are overlain by Made Ground associated with the previous and existing development of the Site.

2.4 Proposed Development

2.4.1 The proposed development comprises the demolition of existing structures including storage sheds and redevelopment of existing car park to provide two blocks of three and five storeys residential units together with other associated works, including the provision of storage units, and at-grade car and cycle parking.

2.4.2 An area of at-grade communal open green space will be provided between the apartment blocks together with a border of soft landscaping along the southwest boundary of the Site.

3.0 Ground Investigation

3.1 Historical Borehole Records

3.1.1 The British Geological Survey archives contain records from a number of exploratory holes and water wells sunk in the vicinity of the Site. Copies of four borehole records have been obtained from the archives and are reproduced in the Phase 1 Ground Condition Assessment (PBA, 2019), these comprise:

i) The record of three boreholes, denoted Boreholes A to C in this report, sunk in 1957 on the site of Torridon House immediately southwest of the Site.

ii) The record of a single borehole, denoted Borehole GPO11 in this report, sunk in 1951 on a site on Edgware Road about 100 m southeast of the Site.

3.1.2 The information presented on these records is consistent with the stratigraphy presented on the published geological map and indicates the London Clay extends to about 45 m below ground level in the area of the Site.

3.2 Recent Ground Investigation

3.2.1 The ground conditions on the Site have been investigated by an intrusive ground investigation to provide information for the redevelopment of the Site. The scope of works is summarised in the following sections of this report. The factual results of the investigation are presented in a separate report prepared by Concept Engineering Consultants Limited (CEC, 2019) which should be read in conjunction with this report.

Aim of the Investigation

3.2.2 The aim of the investigation was to determine the ground conditions within the area of Site such that informed decisions on the proposed development of the Site can be made. The principal aims of the investigation were to determine:

i) The geotechnical characteristics of the ground to provide information for the design of foundations and other geotechnical elements of the development.

ii) The presence and depth of any shallow groundwater in the near surface soils.

iii) The potential for contamination of the ground and groundwater, and the potential for hazardous ground gases to be present.

3.2.3 To satisfy the aims of the investigation, the proposed design of the ground investigation allowed for:

i) Two boreholes to a maximum depth of 35.0 m below existing ground level with standard penetration testing and recovery of thin walled soil samples.

ii) Four window boreholes to a maximum depth of 6.0 m below existing ground level with standard penetration testing, the recovery of soil samples and installation of groundwater and ground gas monitoring wells in each borehole.

iii) Four observation pits to obtain information on the foundations to the boundary walls and existing services on the Site.

iv) Visits to site on six occasions to measure groundwater levels and concentrations of ground gases, including recovery of groundwater samples on a single occasion.

v) Laboratory testing to determine geotechnical properties and concentrations of potential contaminants of the soils and groundwaters encountered.

3.2.4 The scope of the investigation was intended to provide information on the ground conditions to inform the design of the foundations and geotechnical elements of the proposed development and to constitute a detailed investigation for potential contaminants and ground gases as outlined in BS 10175 (2017).

3.2.5 With regard to the investigation for potential contamination of the ground and ground gases, a non-targeted investigation strategy was adopted for the Site because the available information on the history of the Site indicates that no significant potential sources of contamination or hazardous ground gases are likely to be present.

3.2.6 The number of exploratory holes was selected from consideration of the recommendations given in BS 10175 (2017) for detailed investigation of a site with a low potential for contamination to be present making allowance for the expected homogeneous conditions on the Site. Sampling depths were selected to ensure that representative material from the various strata encountered were recovered for laboratory testing to ensure that information on the distribution of potential contaminants in the soils in the Site could be determined.

Fieldwork

3.2.7 The fieldwork for the ground investigation was carried out between 7 and 18 October 2019. The work comprised the sinking of two boreholes, denoted Borehole 101 and 102; four window sample boreholes, denoted Window Sample 101 to 104; and four observation pits, denoted Observation Pit 101 to 104.

3.2.8 Boreholes 101 and 102 were sunk using light cable percussion techniques to a maximum depth of 35.0 m below existing ground level. The ground conditions were investigated by the recovery of open drive UT100 samples, disturbed small and bulk samples, and standard penetration tests carried out using a split spoon sampler.

3.2.9 Window Samples 101 to 104 were sunk by a small track mounted dynamic sampling drilling rig using percussive sampling techniques to a maximum depth of 6.0 m below existing ground level. The ground conditions were investigated by the recovery of disturbed small and bulk samples, and standard penetration tests carried out using a split spoon sampler. Window Sample 104 was initially terminated at 0.4 m depth on a concrete obstruction and relocated to avoid obstruction.

3.2.10 On completion a monitoring well was constructed in each borehole to allow groundwater levels and concentrations of ground gases to be monitored and samples of groundwater recovered for chemical analysis. Below the base of the installation the borehole was backfilled and sealed with bentonite pellets.

3.2.11 Observation Pits 101 to 104 were excavated using hand held equipment to depths between 0.5 and 1.3 m to obtain information on existing underground services and foundations to existing structures adjacent to the Site.

3.2.12 The records of the exploratory holes are presented the factual report (CEC, 2019) and their locations are shown on the Site Layout Plan, **Figure 2**.

Geotechnical Laboratory Testing

3.2.13 A programme of geotechnical laboratory soils testing was carried out to verify the visual identification and classification, and to determine the physical properties of selected samples of the materials encountered.

3.2.14 The testing was scheduled by PBA and carried out in accordance with BS 1377 (1990) by Concept Engineering Consultants, who hold UKAS accreditation for geotechnical soil testing carried out. The results of the geotechnical testing are presented in the factual report (CEC, 2019).

Geochemical Laboratory Testing

3.2.15 A programme of geochemical laboratory testing was carried out on selected soil and water samples to determine the concentrations of a range of commonly occurring potential contaminants. Samples of soil for geochemical testing were taken from the exploratory holes and samples of water recovered from the installed monitoring wells.

3.2.16 The geochemical analyses were scheduled by PBA and carried out by Derwentside Environmental Testing Services Limited, acting on behalf of Concept Engineering Consultants. The geochemical analyses used methods that are accredited by MCERTS where available. The results of the geochemical analyses are presented in the factual report (CEC, 2019).

Monitoring

3.2.17 The monitoring well installed in the borehole as part of the investigations has been monitored to determine the water level together with concentrations of methane, carbon dioxide and oxygen together with gas flow rates and differential and atmospheric pressure.

3.2.18 The monitoring was carried out on six visits at nominal two week intervals from 25 October 2019 and 20 January 2020 which included periods of falling atmospheric pressures. The monitoring results are presented in the factual report (CEC, 2019).

4.0 Ground Conditions

4.1 Stratigraphy

4.1.1 The ground conditions in the area of the Site, as revealed by the ground investigations, comprise Made Ground overlying the London Clay Formation. These ground conditions are consistent with the published geological information and known history of the Site.

4.1.2 Based on the information from the historical borehole records and recent ground investigation, the ground conditions encountered are summarised in the following table.

Summary of Ground Conditions

Formation	Top of Stratum, m bgl[1] (m OD)	Thickness, m	Description
Made Ground	Ground Level	0.5 to 1.5	Surface pavement of asphalt overlying thick beds (0.25 to 0.6 m) of intermixed SAND and GRAVEL of brick, concrete and clinker, locally containing thin beds (0.05 to 0.1 m) of concrete and asphalt. Generally underlain by firm brown slightly sandy CLAY with some gravel of brick, concrete and asphalt.
London Clay	0.5 to 1.5 (30.6 to 32.0)	~45.0	Firm brown CLAY grading with increasing depth to stiff and very stiff grey fissured CLAY.

Note: (1) denotes below ground level

4.1.3 Comments on the nature and extent of each stratum are presented in the following sections of this report. Where characteristic values of parameters for geotechnical design are suggested in the discussion on ground conditions below, reference should be made to the terminology and definitions given in BS EN 1997-1 (2013) and BS EN 1997-2 (2007) as appropriate.

4.2 Made Ground

4.2.1 **Description** Made Ground was encountered within each of the exploratory holes from ground level to between 0.5 and 1.5 m below existing ground level (corresponding to reduced levels between 30.6 and 32.0 m OD).

4.2.2 The near-surface Made Ground was found to comprise a surface layer of asphalt paving typically overlying intermixed brown SAND and GRAVEL of brick, concrete and man-made materials. Locally thin beds of asphalt and concrete were encountered within the Made Ground.

4.2.3 The near surface Made Ground was generally underlain by firm brown slightly sandy CLAY with some gravel of brick, concrete, asphalt and other man-made materials. No visual and olfactory evidence of contamination was noted during the fieldwork.

4.2.4 Details of the underground services, foundations and other structural elements encountered are presented on the individual exploratory hole records presented in the factual report (CEC, 2019).

4.2.5 **Characteristic Values** Given the limited thickness of the Made Ground, this material should be neglected in any design analysis, hence no characteristic values are recommended.

4.3 London Clay Formation

4.3.1 **Description** The London Clay Formation was encountered at all locations investigated where the Made Ground was fully penetrated. The London Clay was typically found to comprise brown CLAY grading with increasing depth to grey extremely closely fissured CLAY.

4.3.2 The London Clay was encountered to the maximum depth investigated of 35.0 m below existing ground level corresponding to a reduced level about -2.9 m OD.

4.3.3 **Classification** Results of classification testing are presented on a Casagrande Chart on **Figure 3**, and indicate the London Clay is typically of very high plasticity with measured values of liquid and plastic limit typically between about 70 and 80, and between about 25 and 30, respectively, with corresponding values of plasticity index typically between about 45 and 50. Measured values of moisture content are typically between 25 and 28 per cent.

4.3.4 Determined values of bulk unit weight are presented as a plot against depth below ground level on **Figure 4** and are typically between about 19.0 and 19.5 kN/m^3.

4.3.5 **Undrained Shear Strength** Visual examination of the material indicates the clay is typically firm, grading to stiff or very stiff in consistency with increasing depth. Values of undrained shear strength, as determined by laboratory triaxial testing of 100 mm diameter specimens, are presented as a plot against depth below ground level on **Figure 5** together with values of undrained shear strength determined using an empirical correlation with SPT N values (Stroud, 1989). The determined values are variable, typically being in the range 50 to 250 kPa with a general trend of increasing strength with increasing depth below ground level.

4.3.6 **Characteristic Values** From consideration of the measured values and properties of the material, an undrained shear strength profile increasing from 50 kPa at 1.5 m depth to 150 kPa at 14.0 m depth and 225 kPa at 35 m depth, as drawn on **Figure 5** is considered appropriate for design analysis.

4.3.7 Values of undrained and drained Young's modulus, E_{vu} and E_v' for vertical loading conditions have been selected from empirical correlations with undrained shear strength, s_u, derived from published back analysis of observed ground movements (CIRIA, 2001) using correlation factors of E_{vu}/s_u of 400 and E_v'/s_u of 240.

4.3.8 Bulk unit weight of this material may be taken to be 19.0 kN/m^3 to 5.0 m depth and 19.5 kN/m^3 below 5.0 m.

4.4 Groundwater

4.4.1 **Groundwater Entries** During the fieldwork for the ground investigation, groundwater entries were generally not noted in the exploratory holes. The exceptions comprise local seepages of groundwater from the Made Ground. It is expected that the general absence of any groundwater entries was due the short time that the exploratory holes were open and the expected low mass permeability of the soils on the Site.

4.4.2 Notwithstanding the general absence of groundwater entries during the ground investigation it is possible that inflows of groundwater from local accumulations of free water within more permeable material present in the Made Ground may be observed during future construction works.

4.4.3 **Groundwater Levels** Recorded groundwater levels in the monitoring wells installed in the boreholes indicate groundwater level is typically between about 0.3 and 0.7 m below ground level (31.8 to 32.1 m OD). The shallower groundwater levels were associated with perched water on the layers of concrete encountered within the Made Ground. It should be noted, that locally higher water levels may be present following periods of prolonged rainfall.

4.4.4 In addition, it is known that water levels in monitoring wells installed in clay soils can take many months to reach equilibrium, as such the measured groundwater levels may not be representative of long term equilibrium conditions.

4.4.5 **Characteristic Value** From consideration of the ground conditions and the geomorphological setting of the Site, it is recommended that a groundwater level 0.5 m below general ground level is assumed for design analysis. Corresponding reduced levels are about 32.0 m OD.

4.4.6 **Infiltration** For drainage design it should be assumed that the soils on the Site are, for practical purposes, impermeable.

5.0 Geoenvironmental Conditions

5.1 Contamination

Geochemical Testing

5.1.1 Geochemical testing was carried out on 12 samples of soil for a range of general industrial contaminants, together with speciated determination of polynuclear aromatic hydrocarbons (PAH) and carbon banding of total petroleum hydrocarbons (TPH). The results of the analysis for general industrial contaminants, PAH and TPH of soil samples carried out are summarised on **Tables 1a** to **1c**, respectively. Geochemical testing was also carried out on 5 samples of groundwater for a range of general industrial contaminants and the results of the analysis are summarised on **Table 2**. Full results of the chemical analysis are presented in the factual report of the ground investigation (CEC, 2019).

Contamination Assessment Regime

5.1.2 **Soils** The results of the geochemical testing on the soil samples have been compared to the Category 4 Screening Levels (C4SL) for residential with home grown produce, residential without home grown produce and residential open space land uses prepared under the auspices of DEFRA (CL:AIRE, 2014). Where a C4SL is not available the concentrations have been compared against the Land Quality Management Ltd (LQM) Suitable 4 Use Levels (S4UL) for the selected land uses (CIEH, 2015).

5.1.3 The additive effect of the hydrocarbon fractions is considered by calculating a hazard quotient for each carbon banding which is the concentration divided by the fraction S4UL criterion for the selected land use. The hazard quotients are added together to give a Hazard Index for each sample assessed. A Hazard Index that exceeds unity can be indicative of a potentially significant human health hazard.

5.1.4 Full details of the assessment criteria are given in a guidance note included after the text of this report.

5.1.5 **Groundwaters** Under the EC Groundwater Daughter Directive the quality of groundwater is related to the potential to adversely impact the quality of surface waters and the potential for use as a water resource. On this basis the quality of groundwaters has been assessed in relation to the directions to the Environment Agency in regard to the implementation of the Water Framework Directive (WFD) (Defra, 2010) and the UK drinking water quality standards (DETR, 2000). However, given that the groundwaters on the Site do not feed directly into surface waters and are not abstracted for drinking, the selected criteria are not strictly applicable, and in the context of this appraisal, solely provide a conservative framework for assessing the quality of the groundwater on the Site. Full details of the assessment criteria are given in a guidance note included after the text of this report.

5.1.6 **Analysis of Data** Guidance prepared under the auspices of DEFRA (CEIH, 2008) promotes the use of statistical analysis of the measured concentrations of potential contaminants. The outlier test identifies measurements that are large, or small, relative to the rest of the data and, therefore, suspected of misrepresenting the population from which they were collected. The one sample t-test provides an estimate of the upper bound concentration which the actual mean concentration will be below 19 times out of 20. Use of the outlier and one sample t-tests provides a robust statistical methodology for the assessment of concentration of potential contaminants.

Assessment of Contamination

5.1.7 **Soils** The measured concentrations of potential contaminants, as summarised on **Tables 1a** to **1c**, are generally below the selected assessment values appropriate for a residential with home grown produce end use and the less onerous residential without home grown produce and residential open space land uses. The exceptions comprise slightly elevated concentrations of lead and speciated PAH (dibenzo(a,h)anthracene) measured in separate samples of Made Ground. Although generally below the assessment criteria, marginally elevated concentrations of other potential contaminants were also measured.

5.1.8 Identifiable pieces of asbestos containing materials were not noted during the fieldwork, however asbestos containing material was identified in 1 of 12 soil samples screened prior to chemical analysis; the asbestos containing material comprised loose chrysotile fibres. Quantification analysis determined the proportion of asbestos to be about 0.006 per cent, that is marginally above the reported limit of detection for the quantification analysis.

5.1.9 The results of the analysis are indicative of a general spread of isolated 'point' sources of potential contaminants consistent with the presence of scattered fragments of man-made materials in the Made Ground from the previous and current development and use of the Site.

5.1.10 **Groundwaters** The measured concentrations of potential contaminants, as summarised on **Table 2**, are generally below the selected assessment criteria for assessing potential groundwater impacts on surface waters and below the UK drinking water quality standards. The exceptions include marginally elevated concentrations of a number of heavy metals (cadmium, copper and selenium). A specific reason for the elevated concentrations is not known but they are expected to reflect the background quality of the groundwater in the vicinity of the Site owing to the general urban environment, rather than any contamination actually arising from the Site.

Off Site Disposal

5.1.11 For the samples of Made Ground analysed, the measured concentrations of selected potential contaminants were below the assessment values appropriate for a residential with home grown produce land use. On this basis, it is expected that any Made Ground to be disposed of off-site may be classified as non-hazardous waste although additional testing of any unusual solid materials or liquids encountered during the construction works may be required to confirm the actual classification prior to off-site disposal. Any material to be disposed of off-site that contains identifiable pieces of asbestos containing material or more than 0.1 per cent free and dispersed asbestos fibres would be classified as hazardous waste.

5.1.12 The natural soils on the Site are not likely to contain significant concentrations of contaminants and in accordance with the criteria set in Part 3, of the Landfill (England and Wales) Amendment Regulations 2004, the natural soils at the Site are likely to be classified as inert.

5.1.13 Particular care will be required in excavating material to identify and wherever practicable to segregate any potentially contaminated materials to ensure they do not adversely affect the classification of other excavated materials.

5.2 Ground Gases

5.2.1 The concentrations of ground gases and gas flows measured in the gas monitoring wells installed in the near-surface soils are presented in the factual report of the ground investigation (CEC, 2019) and summarised in the following table.

Summary of Ground Gases Monitoring

Gas	Concentration/Flow
Methane, %v/v	<0.1

Gas	Concentration/Flow
Carbon Dioxide, %v/v	<0.1 to 1.2
Oxygen, %v/v	<0.1 to 20.4
Gas Flow, l/hr	<0.5(1)

Note (1) Elevated equilibrium flow rates up to 15 l/s were measured in Borehole 102 on a single visit.

5.2.2 The measured concentrations of ground gases indicate predominantly near atmospheric conditions are present in the near-surface soils across the Site. The exceptions are locally marginally elevated concentrations of carbon dioxide and corresponding reduced levels of oxygen. It is expected that the elevated concentrations of carbon dioxide are associated with the biodegradation of organic matter within the near-surface soils.

5.2.3 Using the procedure for classifying gassing sites proposed by BS 8485 (2015), the monitoring data indicates the ground gases in the near-surface soils may be classified as Characteristic Situation 1. This Situation is representative of ground with a very low potential for gas generation. For Characteristic Situation 1, BS 8485 (2015) advise that gas protection measures are not required.

5.3 Assessed Land Contamination Risk

5.3.1 An assessment of the potential risk to the proposed development was carried out using a Conceptual Site Model to identify 'source-pathway-receptor' linkages, and is presented in the Phase 1 Ground Condition Assessment (PBA, 2019).

5.3.2 The findings of the ground investigation are in general agreement with the information available for the Phase 1 Ground Condition Assessment (PBA, 2019) and indicate that the potential for significant contamination to be present on the Site is **Low** whilst the potential for any deleterious material producing hazardous ground gases to be present is **Very Low**. Therefore, the assessed risk to human health remains, in general, **Very Low** as previously assessed in the Phase 1 Ground Condition Assessment (PBA, 2019).

5.3.3 The potential exception is the risk to site workers during the construction phase owing to the potential for unexpected contamination to be encountered during the ground works. Measures to be adopted to mitigate the risk to site workers will include (i) the provision of appropriate protective clothing and equipment and; (ii) the adoption of good standards of hygiene to prevent prolonged skin contact, inhalation and ingestion of soils during construction.

5.3.4 With regard to future site users, it is expected that the proposed buildings and hard surfaces, together with the topsoil/subsoil to the proposed private gardens will be sufficient to ensure the potential risk to future site users associated with contaminated material is **Very Low**.

5.3.5 It must be noted that there is a possibility that unexpected sources of contamination associated with, for example, disposal of asbestos and other construction material during previous construction works or the storage and use of fuel oils may be encountered during the site clearance or ground works. It is recommended that specific management procedures are put in place in the event that any unusual solid materials or liquids are encountered during the construction works.

6.0 Geotechnical Assessment

6.1 Geotechnical Considerations

6.1.1 For the proposed development, the principal geotechnical consideration is the strength and compressibility of the founding soils and hence, the foundation requirements for the proposed buildings. This section of the report presents comments on the ground conditions in relation to design and construction of the geotechnical elements of the proposed structures.

6.1.2 Recommended characteristic values of parameters for geotechnical design as determined from consideration of the results of geotechnical testing carried out on samples of the soils recovered during the ground investigation and consideration of published data and correlations with index properties are discussed in **Section 4** of this report and are summarised in the following table.

Summary of Recommended Characteristic Values

Formation	Bulk Unit Weight, kN/m^3 (m bgl)(1)	Undrained Shear Strength, kPa (m bgl)(1)	Drained Elastic Modulus(2), MPa (m bgl)(1)
Made Ground	18.0	-(4)	5
London Clay(3)	19.0 (<5.0) 19.5 (>5.0)	50 (at 1.5) 150 (at 14.0) 225 (at 35.0)	12 (at 1.5) 36 (at 14.0) 54(at 35.0)

Notes (1) Denotes below ground level.
(2) Values are appropriate for effective stress conditions under vertical loading conditions.
(3) Intermediate values determined by linear interpolation.

6.1.3 It is recommended that a groundwater level 1.0 m below general ground level is assumed for design analysis. Corresponding reduced levels are about 31.5 m OD.

6.1.4 The recommended characteristic values should be reviewed and selected by the Geotechnical Designer taking into consideration the limit states and design methods being used, and the process should be documented in the Geotechnical Design Report.

6.2 Site Preparation

6.2.1 It is expected that the proposed development will largely be constructed at grade on the existing ground profile. However, local excavation of trenches and ditches will be required associated with the construction of the site infrastructure, foundations, et cetera.

Excavation Works

6.2.2 The soils to be excavated comprise the sandy gravel, sandy clay and clay of the Made Ground and the upper part of the underlying London Clay.

6.2.3 Excavation of the surface pavements, any existing foundations and below ground structures and other obstructions to foundation works are likely to require pre-treatment by use of hydraulic breakers to fracture the material. Once fractured, it should be possible to excavate these material and the underlying soils using conventional tracked excavators. Any remains of walls, foundations et cetera should be removed to 1.0 m below formation level to prevent any development of concentrations of stress in floor slabs and pavements.

6.2.4 Although no significant difficulties were experienced in advancing the exploratory holes through the Made Ground owing to the presence of artificial obstructions, given the historical development of the Site the presence of obstructions to excavations during the construction works cannot at this time be discounted.

6.2.5 Particular care will be required in excavating any walls, foundations et cetera around the perimeter of the Site to ensure the works do not compromise the stability of the neighbouring properties, and footpaths and infrastructure outside of the site boundary.

6.2.6 It is essential that contractors carefully inspect and check the exposed formation for evidence of localised weak areas and possible voids, such as old wells or trenches, and take appropriate measures to ensure the adequacy of the exposed formation.

Groundwater Control

6.2.7 As discussed in **Section 4.4**, groundwater levels are expected to be present at shallow depth. The general absence of groundwater entries into the exploratory holes during the ground investigation indicates the near-surface soils typically have a low mass permeability. It should be noted, however, that inflows of groundwater from local accumulations of free water within more permeable material present in the Made Ground are expected to be observed during construction works.

6.2.8 Allowance should be made for controlling any inflows of groundwater from the Made Ground, together with inflows of any water within any disused drains encountered during the works and surface water inflows during periods of wet weather. Based on the visual examination of the materials encountered groundwater inflows during construction are, in general, expected to be of limited volume and should be controlled by the construction of drainage ditches and pumping from sumps within the excavations as appropriate. Disposal of the water to the foul sewerage system will require agreement with the local water authority.

Stability of Excavations

6.2.9 Although the sides of trenches and areas of open cut may initially stand with near-vertical side slopes, these should be either battered back to a safe slope angle or retained by full-face support to ensure their stability in the short and medium term. The temporary safe slope angle will depend on the nature and strength of the material around the excavation and it is expected that temporary safe slope angles to excavations will typically be between about 35 and 40 degrees to the horizontal (CIRIA, 1992).

Backfill to Excavations

6.2.10 Where the excavation of existing foundations and below ground structures is below the formation level for the proposed development, the excavations will need to be filled to the required formation level. Given the limited plan area of the Site it is expected that there will be no provision for temporary on site storage of excavated material. As such all excavated material would be removed directly from Site on excavation for disposal offsite to a suitably licensed facility.

6.2.11 On this basis, any fill to excavations would need to be carried out using imported general fill material. It is recommended that any general backfill to excavation is carried out using imported granular fill that is placed and compacted in accordance with an engineering specification.

6.3 Foundations

6.3.1 Based upon the ground conditions encountered on the Site, shallow spread footings founded within the undisturbed London Clay Formation may be an appropriate option for founding the proposed three storey block, whilst it is expected that pile foundations will be required for the proposed five storey block.

Spread Foundations

6.3.2 **Presumed Bearing Value** In accordance with the guidance given in NHBC (2019), it is recommended that shallow pad or strip footings are formed in undisturbed natural soils 0.3 m below the base of any soft or disturbed ground or a minimum of 1.0 m below existing or the proposed final ground level, whichever is the greatest. On this basis, a presumed bearing value not exceeding 80 kPa may be used to make a preliminary determination of the required dimensions of shallow pad or strip footings. Once the detailed foundation loads are known, the dimensions of the footings should be verified for the various design limit states in accordance with the requirements of BS EN 1997-1 (2013). Guidance on minimum foundation width is given in BS 8103 (2011) and NHBC (2019).

6.3.3 **Settlement** It is estimated that foundation settlements will be about 15 to 20 mm for pad or strip footings up to about 1.0 m in width. It is expected that about half of the settlement will comprise short-term elastic settlement. The short term elastic settlement will take place during the construction work as the structure is loaded and hence the residual long term settlement is likely to be about 10 mm. Once the detailed foundation loads and dimensions are known, the total and potential differential foundation settlements (short and long term), both beneath and between individual foundations should be determined.

6.3.4 **Effect of Trees** In accordance with the guidance given in NHBC (2019), the near-surface soils are shrinkable typically having a high volume change potential. Due allowance should be made in the design of foundations for the past, present or future presence of the trees adjacent to the proposed development. In this regard, shallow foundations should be designed in accordance with the guidelines for foundations on a soil with a high volume change potential given in Chapter 4.2 of the NHBC Standards (NHBC, 2019). In accordance with this guidance, the mature height of any trees retained or to be planted should be taken into consideration, whereas the effects of desiccation from trees or hedges that have been removed will be related to their size when felled.

6.3.5 **Disturbed Ground** Given that disturbed ground or otherwise unsuitable soils may be present at the formation level, it is recommended that all bearing surfaces be inspected by a qualified geotechnical engineer prior to constructing the foundations. Any soft or loose soil encountered at foundation level should be removed and replaced with well compacted granular fill or foundation concrete. The bearing surface should be rolled to re-compact any soils disturbed during excavation.

Pile Foundations

6.3.6 **Pile Construction** For the ground conditions present at the Site, bored and cast-in-place piles are typically the most efficient means of carrying foundation loads for the proposed apartment blocks. Such piles formed using conventional rotary auger techniques or continuous flight auger techniques should be appropriate although the presence of any existing foundations, below ground structures or mudstone/claystone layers in the London Clay may form obstructions to piling works. If conventional rotary auger techniques are used, temporary casing in the Made Ground and upper part of the London Clay may be needed to support the pile bore and to exclude groundwater

6.3.7 **Axial Load Capacity** The axial load capacity of the piles may be determined from the characteristic values recommended in **Section 4.0** using the static design procedures and the partial and model factors given in BS EN 1997-1 (2013). In these procedures the axial capacity of the pile is taken to be the sum of the adhesion on the pile shaft and the end bearing resistance on the pile base.

6.3.8 For the London Clay, the adhesion on the pile shaft is related to the undrained shear strength of the founding clay by an adhesion factor. The value of adhesion factor depends on the degree of softening and stress relief in the clay around the pile during boring and prior to concreting. Given the low mass permeability of the soils on the Site it is expected that the pile bore will remain essentially dry and that softening of the clay will be limited. For such conditions an adhesion factor of 0.5 is considered appropriate for the London Clay (LDSA, 2009). If significant groundwater inflows into the pile bore are noted then consideration should be given to adopting lower values of adhesion factor in the design of the piles to allow for softening of the clay around the pile.

6.3.9 For the London Clay, the end bearing on the pile toe may be taken as nine times the undrained shear strength of the clay immediately below the toe (LDSA, 2009). Appropriate techniques will need to be adopted to clean the pile bore sufficiently to ensure that full end bearing can be realised.

6.3.10 The axial pile resistance should be determined using appropriate partial factors on soil properties, actions and resistances to determine the adequacy of the pile design (BS EN 1997-1, 2013). Preliminary estimates of the axial resistance and pile head stiffness for the COM2 limit state of 450, 450 and 600 mm uniform diameter piles have been made using the static design procedures and the partial and model factors given in BS EN 1997-1 (2013); the preliminary estimates are presented in the table below.

Preliminary Estimates of Axial Resistance and Pile Head Stiffness (COM2 limit state)

Pile Toe Level, m bgl	Axial Resistance, kN(1) [Pile Head Stiffness, MN/m3(2)]		
	350 mm	450 mm	600 mm
20.0	600 [2950](3)	8005 [2350]	1100 [1650]
25.0(4)	825 [2750](3)	1075 [2300](3)	1500 [1800]
30.0(4)	1075 [2550](3)	1400 [2200](3)	1925 [1800]

Notes
(1) Axial resistances calculated assuming no explicit verification of serviceability limit state and without verification of ultimate limit state by maintained load test.
(2) Pile head stiffness determined from pile head settlements estimated using the procedure given by Fleming (1992).
(3) Pile length exceeds 50 times pile diameter (LDSA, 2009).
(4) CFA piling rigs often have a maximum pile length of 23 m hence discussions with piling contractors will be required if longer piles are proposed to ensure they can be constructed.

6.3.11 These values are appropriate for single isolated piles and have been determined assuming that no bending or horizontal loads are applied to the pile. The actual resistance of a pile will be dependent on the method of installation and technique used. The actual pile capacity should therefore be established with reference to the piling contractor during detailed design. Pile integrity testing should be carried out to confirm the design and workmanship. Consideration may be given to carrying out pile loading tests to verify the design and hence allow lower partial factors to be adopted.

6.3.12 The preliminary estimates of axial resistance presented above are given to inform the conceptual design of the proposed structure only. Design of the piles will need to be carried out by the appointed Geotechnical Designer taking into account the partial factors on soil properties, actions and resistances should be applied in accordance with the requirements of BS EN 1997-1 (2013).

6.4 Ground Floor Slabs

6.4.1 Based on the ground conditions encountered at the Site, it is expected that, in general, ground floor slabs supported on a suitable thickness of sub-base will prove adequate provided the exposed natural deposits are compacted by a heavy smooth wheeled roller and any soft or degradable materials removed and replaced with compacted granular fill.

6.4.2 The exceptions include areas where the depth of Made Ground below the sub-base exceeds 600 mm and areas within the zone of influence of trees which are to remain or be removed. In these areas consideration should be given to designing and constructing the floor slabs to be suspended.

6.5 Pavement Design

6.5.1 Pavements carried on a suitable depth of capping/sub-base should prove adequate provided the exposed deposits are compacted by a heavy smooth wheeled roller and any soft or degradable materials removed and replaced with compacted granular fill. Similarly any remains of walls, foundations or exposed pieces of demolition material would need to be removed to prevent any development of concentrations of stress in the pavement.

6.5.2 It is recommended that design CBR values be selected from consideration of the long-term equilibrium values proposed by HA (1994). The CBR value of the near surface soils should be taken to be 2.5 per cent. A geotextile should be placed to ensure separation of the granular fill from the formation. The near surface soils may be susceptible to frost damage and it is recommended that a minimum pavement thickness of 450 mm is provided.

6.6 Aggressiveness of the Ground

Design Class of Buried Concrete

6.6.1 The measured pH values and sulphate concentrations measured on samples of soils and groundwaters recovered as part of the recent investigation are presented in the factual report on the investigation (CEC, 2019) and are summarised on the following table.

Summary of Chemical Environment for Concrete Mix Design

	Number of Tests	pH Value	Water Soluble Sulphate (g/l)	Acid Soluble Sulphate (%)	Total Sulphur (%)
Made Ground	11	8.0 to 11.4	0.05 to 0.38	-	-
London Clay	8	7.7 to 9.0	0.35 to 4.50	0.09 to 1.93	0.26 to 1.04
Groundwater	4	7.3 and 8.2	0.46 and 3.02	-	-

6.6.2 For the static groundwater conditions in the London Clay Formation, the measured concentrations of soluble sulphates in the soils and groundwaters correspond to Design Sulphate Class DS-4 and ACEC Class AC-3s conditions as defined by BRE (2005). The recommendations of BRE (2005) should be followed in the design of mixes for buried concrete for the classification given.

Design of Water Supply Pipes

6.6.3 The concentrations of potential contaminants measured as part of the ground investigations indicate no significant potential contaminants are present in the area of the proposed development. On this basis, it is unlikely that contamination of the water supply will occur or that specific mitigation measures will need to be taken in the design and construction of the water supply pipes.

6.6.4 Notwithstanding the previous comment, under the Water Supply (Water Fittings) Regulations (DETR, 1999), the Water Supplier has a statutory duty to ensure that the design and material selection for water supply pipes are suitable and their advice and recommendations should be sought with regard to the water supply pipes for the proposed development. It should be noted that the Water Supplier may require additional testing to be carried out.

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GUIDANCE NOTES

Essential Guidance on the Context of the Report

This report has been prepared within an agreed timeframe and to an agreed budget that will necessarily apply some constraints on its content and usage. The remarks below are presented to assist the reader in understanding the context of this report and any general limitations or constraints. If there are any specific limitations and constraints they are described in the report text.

1) The opinions and recommendations expressed in this report are based on statute, guidance, and appropriate practice current at the date of its preparation. Peter Brett Associates LLP (PBA) does not accept any liability whatsoever for the consequences of any future legislative changes or the release of subsequent guidance documentation, etc. Such changes may render some of the opinions and advice in this report inappropriate or incorrect and we will be pleased to advise if any report requires revision due to changing circumstances. Following delivery of the report PBA has no obligation to advise the Client or any other party of such changes or their repercussions.

2) Some of the conclusions in this report may be based on third party data. No guarantee can be given for the accuracy or completeness of any of the third party data used. Historical maps and aerial photographs provide a “snap shot” in time about conditions or activities at the site and cannot be relied upon as indicators of any events or activities that may have taken place at other times.

3) The conclusions and recommendations made in this report and the opinions expressed are based on the information reviewed and/or the ground conditions encountered in exploratory holes and the results of any field or laboratory testing undertaken. There may be ground conditions at the site that have not been disclosed by the information reviewed or by the investigative work undertaken. Such undisclosed conditions cannot be taken into account in any analysis and reporting.

4) Unless specifically stated to the contrary, this report does not purport to be a “Geotechnical Design Report” as defined in Clause 2.8 of Eurocode 7 (Geotechnical Design BS EN 1997-1:2004). Some of the data contained herein and used to support any geotechnical assessment presented in this report may be historical or for other reasons not fully compliant with the requirements of that code.

5) It should be noted that groundwater levels, groundwater chemistry, surface water levels, surface water chemistry, soil gas concentrations and soil gas flow rates can vary due to seasonal, climatic, tidal and man made effects.

6) If the report indicates that asbestos has been identified within the ground, any work that involves, or is likely to involve, contact with asbestos must be undertaken in accordance with the Control of Asbestos Regulations 2012, particularly in regard to risk assessment, licensing and training. A risk assessment should be carried out prior to any activities that could lead to the disturbance of asbestos materials, either buried or on the ground surface and should include appropriate mitigation measures, such as damping down to prevent the spread of asbestos, air monitoring and minimum PPE and/or RPE requirements for the work proposed.

7) This report has been written for the sole use of the Client stated at the front of the report in relation to a specific development or scheme. The conclusions and recommendations presented herein are only relevant to the scheme or the phase of project under consideration. This report shall not be relied upon or transferred to any other party without the express written authorisation of PBA. Any such party relies upon the report at its own risk.

8) The interpretation carried out in this report is based on scientific and engineering appraisal carried out by suitably experienced and qualified technical consultants based on the scope of our engagement. We have not taken into account the perceptions of, for example, banks, insurers, other funders, lay people, etc, unless the report has been prepared specifically for that purpose. Advice from other specialists may be required such as the legal, planning and architecture professions, whether specifically recommended in our report or not.

9) Public or legal consultations or enquiries, or consultation with any Regulatory Bodies (such as the Environment Agency, Natural England or Local Authority) have taken place only as part of this work where specifically stated.

1 Introduction

The aim of this document is to present an explanation for the selection of the assessment criteria routinely used by PBA when undertaking a Tier 2 (generic) contamination risk assessment.

A Tier 2 assessment is a quantitative assessment using published criteria to screen the site-specific contamination testing data and identify potential hazards to specific receptors. Generic criteria are typically conservative in derivation and exceedance does not indicate that a site is statutorily contaminated and/or unsuitable for use in the planning context. These criteria are used to identify situations where further assessment and/or action may be required.

This document is divided into general introductory text and sections on soils, waters and gases.

2 General Notes

This document should be read in conjunction with another entitled “PBA Methodology for Assessment of Land Contamination” which summarises the legislative regime and our approach to ground contamination and risk assessment.

Any PBA interpretation of contamination test results is based on a scientific and engineering appraisal. The perceptions of, for example, banks, insurers, lay people etc are not taken into account.

Any tables included in this document are produced for ease of reference to the criteria, they do not in any way replace the documents of origin (which are fully referenced) and which should be read to ensure appropriate use and interpretation of the data.

Generic criteria provide an aid to decision-making, but they do not replace the need for sound professional judgement in risk assessment (EA, 2006). The criteria are based on numerous and complex assumptions. The appropriateness of these assumptions in a site-specific context requires confirmation on a project by project basis. Our interpretative report will comment on the appropriateness of the routine criteria for project objectives or ground conditions. In some cases the published criteria whilst typically conservative may in some circumstances not be suitable for the site being assessed, either because they do not address the identified pollutant linkages or because they may not be sufficiently precautionary in the context of the site. Under these circumstances it may be necessary to recommend deriving site-specifc assessment criteria. Any deviation from the routine criteria and/or selection of criteria for parameters not covered in this document will be described in the report text.

3 Criteria for Assessing Soil Results

3.1 Potential Harm to Human Health

The criteria routinely used by PBA as Tier 2 soil screening values for the protection of human health are:-

- LQM/CIEH Suitable 4 Use Levels (S4ULs) (Nathanail *et al*, 2015);
- CL:AIRE/EIC/AGS Generic Assessment Criteria (GAC) (CL:AIRE, 2010);
- Environment Agency Soil Guideline Values (SGVs) (EA, 2009a); and
- Defra Category 4 Screening Levels (C4SLs) (DEFRA, 2014);

These criteria have been generated using the Contaminated Land Exposure Assessment model (CLEA) and supporting technical guidance (EA, 2009b, 2009c, 2009d, 2009e). The CLEA model uses generic assumptions about the fate and transport of chemicals in the environment and a generic conceptual model for site conditions and human behaviour to estimate child and adult exposures to soil contaminants for those potentially living, working, and/or playing on contaminated sites over long time periods (EA, 2009c).

The S4ULs, SGVs and GAC are all based on use of minimal/tolerable risk Health Criteria Values (HCVs) as the toxicological benchmark whereas the C4SL are based on use of a “low level of toxicological concern” (LLTC) as the toxicological benchmark. The LLTC represents a slightly higher level of risk than the HCV.

An update to the software (1.071) was published on 04/09/2015 (handbook (EA 2009f) referring to version 1.05 is still valid). The update includes the library data sets from the DEFRA research project SP1010 (Development of Category 4 Screening Levels for assessment of land affected by contamination).

The CLEA model uses ten exposure pathways (Ingestion (outdoor soil, indoor dust, homegrown vegetables and soil attached to homegrown vegetables), Dermal Contact (outdoor soil and indoor dust) and Inhalation (outdoor dust, indoor dust, outdoor vapours and indoor vapours)). There are exposure pathways not included in the CLEA model such as the permeation of organics into plastic water supply pipes.

The presence and/or significance of each of the potential exposure pathways is dependent on the land use being considered. The model uses standard land use scenarios as follows:-

Residential – habitation of a dwelling up to two storeys high with various default material and design parameters, access to either private or nearby community open space with soil track back to form indoor dust. Assumes ingestion of homegrown produce.

Allotments – the model has default parameters for use and consumption of vegetables but not animals or their products (eggs).

Industrial/Commercial – assumes office or light physical work in a permanent three storey structure with breaks taken outside and that the site is NOT covered in hardstanding.

Public Open Space – two public open space (POS) scenarios are considered: POS_{resi} is shared communal space within a residential development where tracking back of soil into the home is assumed to occur. POS_{park} is intended for a public park sufficiently distant from housing (i.e. not adjacent to housing) such that tracking back of soil into the home is negligible. Note that the POS assessment criteria may not be appropriate for assessing sports fields.

The assessment criteria generated using CLEA can be used as a conservative starting point for evaluating long-term risks to human health from chemicals in soil.

It is important to note that the model does not assess all the potential exposure scenarios, for example risk to workers in excavations (short term exposure) or diffusion of contaminants through drinking water pipes.

Recent guidance (DEFRA 2012) introduces a four stage classification system where Category 1 sites are clearly contaminated land and Category 4 sites are definitely not contaminated land as defined by EPA 1990. Outside of these categories further specific risk assessment is required to determine if the site should fall into Category 2 (contaminated land) or Category 3 (not contaminated land). Category 4 screening values are considered to be more pragmatic than the current published SGV/GAC criteria but still strongly precautionary with the aim of allowing rapid identification of sites where the risk is above minimal but still low/acceptable.

Category 4 Screening Levels (C4SLs)

At the end of 2013, technical guidance in support of DEFRA's revised Statutory Guidance (SG) was published and then revised in 2014 (CL:AIRE 2014) which provided:

- A methodology for deriving C4SLs for the standard land-uses and two new public open space scenarios using the updated assumptions relating to the modelling of human exposure to soil contaminants; and
- A demonstration of the methodology, via the derivation of C4SLs for six substances – arsenic, benzene, benzo(a)pyrene, cadmium, chromium (VI) and lead.

Following issue of an Erratum in December 2014 a Policy Companion Document was published (DEFRA 2014).

A letter from Lord de Mauley dated 3rd September 2014 provides more explicit direction to local authorities on the use of the C4SL in a planning context. The letter identifies four key points:

1) that the screening values were developed expressly with the planning regime in mind
2) their use is recommended in DCLG's planning guidance
3) soil concentrations below a C4SL limit are considered to be 'definitely not contaminated' under Part IIA of the 1990 Environmental Protection Act and pose at most a 'low level of toxicological concern' and
4) exceedance of a C4SL screening value does not mean that land is definitely contaminated land, just that further investigation may be warranted.

Table 1 summarises the C4SL (DEFRA 2014) for each of the six substances. PBA uses the criterion for lead and may use the other criteria, depending on site specific conditions.

Note that an industry led project to derive C4SL for a further 20 substances has commenced (CL:AIRE, 2018). The project is being project managed by CL:AIRE and is funded by the Soil and Groundwater Technology Association (SAGTA), the Society of Brownfield Briefing (SoBRA) and others. A dedicated streering group, made up of representatives from SAGTA, Defra, Welsh Government, Public Health England, Environment Agency, Natural Resources Wales, Food Standards Agency, Homes England and further Land Forum representatives, has been set up to oversee the project. The new C4SL will be added to this document as they are published.

Suitable 4 Use Levels (S4ULs)

In July 2009, Generic Assessment Criteria (GACs) for 82 substances were published by the Chartered Institute of Environmental Health (CIEH) (LQM and CIEH, 2009) using the then current version of the CLEA software v1.04 and replacing those generated in 2006 using the original version of the model CLEA UK *beta*. In 2015 S4ULs were published by LQM/CIEH (Nathanail *et al*, 2015) to replace the second edition GACs. Table 2 summarises the S4ULs which are reproduced with permission; Publication Number S4UL3202.

Soil Guideline Values (SGVs) and Generic Assessment Criteria (GAC)

In 2009, Soil Guideline Values (SGVs) were published by the Environment Agency for arsenic, cadmium, mercury, nickel, selenium, benzene, toluene, ethyl benzene, xylenes, phenol and dioxins, furans and dioxin-like PCBs. These were derived using the CLEA model for residential, allotments and commercial land-uses.

These SGVs have now largely been superceded by the C4SL and LQM/CIEH S4UL, with the exception of the SGVs for dioxins, furans and dioxin-like PCBs which have been adopted as the PBA Tier 2 assessment criteria and which are shown in Table 3.

In January 2010, Generic Assessment Criteria (GAC) derived using CLEA were published by CL:AIRE for 35 substances. These GAC are listed in Table 4.

Note that the SGVs for dioxins, furans and dioxin like PCBs and CL:AIRE GAC were derived using an older version of CLEA (v1.06) than used to derive the S4UL and C4SL (v1.07). This older version used slightly more conservative values for some exposure parameters and therefore the derived SGVs/GAC are still considered suitably precautionary for use as screening criteria.

Note on Mercury, Chromium and Arsenic Assessment The analytical testing routinely undertaken by PBA determines total concentration, however, the toxicity depends on the form of the contaminant.

If a source of Mercury, Chromium or Arsenic is identified or the total concentration exceeds the relevant worst case speciated criteria it will be desirable/necessary to undertake additional speciated testing and further assessment.

Note on Polycyclic Aromatic Hydrocarbons Polycyclic Aromatic Hydrocarbons (PAHs) are a family of hundreds of different congeners whose chemical structures contain 2 or more fused aromatic rings. Whilst it is recognised that there is an ongoing debate on the most appropriate method to assess health effects of PAH mixtures, in 2010 the Health Protection Agency recommended the use of benzo[a]pyrene (BaP) as a surrogate marker approach in the assessment of carcinogenic risks posed by PAHs in soils (HPA, 2010).

In most cases, BaP is chosen as the surrogate marker (SM) due to its ubiquitous nature and the vast amount of data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. The SM approach estimates the toxicity of a mixture of PAHs in an environmental matrix by using toxicity data for a PAH mixture for which the composition is known.

Exposure to the SM is assumed to represent exposure to all PAHs in that matrix therefore the toxicity of the SM represents the toxicity of the mixture. The SM approach relies on a number of assumptions (HPA, 2010).

- The SM (BaP) must be present in all the samples.
- The profile of the different PAH relative to BaP should be similar in all samples.
- The PAH profile in the soil samples should be sufficiently similar to that used in the pivotal toxicity study on which HBGV was based i.e. the Culp study (Culp et al. (1998)).

In order to justify the use of a surrogate marker assessment criterion (C4SL for benzo(a)pyrene and S4UL coal tar) the LQM PAH Profiling Tool is used by PBA to assess the similarity of the PAH profile in a soil sample to that of the toxicity study. The spreadsheet that calculates the relative proportions of the genotoxic PAHs and plots them on the two charts relative to composition of the two coal mixtures used by Culp et al. (the plus/minus an order of magnitude limits suggested by HPA).

Note on Total Petroleum Hydrocarbons

The S4UL for Total Petroleum Hydrocarbon (TPH) fractions are based on 'threshold' health effects. In accordance with Environment Agency guidance (EA, 2005) and the S4UL report (Nathanail *et al*, 2015) the potential for additivity of toxicological effects between fractions should be considered. Practically, to address this issue the hazard quotient (HQ) for each fraction should be calculated by dividing the measured concentration of the fraction by the GAC. The HQs are then added to form a hazard index (HI) for that sample. An HI greater than 1 indicates an exceedance.

Note on Dioxins, Furans and Dioxin-like PCBs

The SGVs for dioxins, furans and dioxin-like PCBs are based on an assumed congener profile for urban soils. The total measured concentration of dioxin, furan and dioxin-like PCB congeners listed in the SGV report (EA, 2009a) should be compared with the SGVs to make an initial assessment of risk. A more accurate assessment can be made using the Environment Agency's site specific worksheet for dioxins, furans and dioxin like PCBs available from https://www.claire.co.uk/useful-government-legislation-and-guidance-by-country/77-risk-assessment-info-ra/199-dioxins-site-specific-worksheets.

Note on Asbestos

Asbestos in soil and made ground is currently under review by a number of bodies. There are no current published guidance values for asbestos in soil other than the waste classification values given in the EA's Technical Guidance WM3, Hazardous Waste – Interpretation of the definition and classification of hazard waste (3rd Edition, EA, 2015). This guidance is only appropriate for soils that are being discarded as waste.

Testing for asbestos will be carried out on selected samples of made ground encountered during investigation, initially samples will be subjected to an asbestos screen and, if asbestos is found to be present, subjected to quantification depending on the project specific requirements. The reader is directed to the report text for guidance on the approach adopted in respect to any asbestos found to be present.

Further guidance is also available in publication C733, Asbestos in soil and made ground: a guide to understanding and managing risks (CIRIA 2014).

Note on Soil Saturation Concentration

The soil saturation concentration is the concentration of an organic constituent in soil at which either the pore water or soil vapour has theoretically become saturated with the substance, i.e. the substance concentration has reached its maximum aqueous solubility or vapour pressure. The soil saturation concentration is related to the properties of the substance as well as the properties of the soil (including soil organic matter content).

The soil saturation concentrations are shown in Table 2 in brackets where exceeded by the assessment criteria and in Table 4 for all substances. Measured concentrations in excess of the soil saturation concentration have various potential implications as discussed below.

Firstly, where measured concentrations exceed the soil saturation concentration, the risk from vapour inhalation and/or consumption of produce may be limited. The CLEA model calculates the soil saturation concentration but it does not limit exposure where this concentration is exceeded. This adds an additional level of conservatism for CLEA derived assessment criteria where these exceed the calculated soil saturation concentration.

Secondly, the soil saturation concentration is sometimes used to flag the potential presence of non aqueous phase liquid (NAPL, a.k.a. free phase) in soil. The presence of NAPL is an important consideration in the Tier 2 assessment because, where present, the risks from NAPL may need to be considered separately. Theoretically, where a measured concentration exceeds the soil saturation concentration NAPL could be present. However, using theoretical saturation values is not always reliable for the following reasons:The soil saturation concentration is based on the aqueous solubility and vapour pressure of a pure substance and not a mixture, of which NAPLs are often comprised; and

The soil saturation concentration does not account for the sorption capacity of the soil. As a result, exceedance of the soil saturation concentration does not necessarily imply that NAPL is present. This is particularly the case for longer chain hydrocarbons such as PAHs which have low solubility and vapour pressure and hence a low soil saturation concentration but that are strongly sorbed to soil.

The PBA Tier 2 Assessment will compare measured concentrations with the soil saturation concentrations shown in Tables 2 and 4. Where exceeded PBA will use additional lines of evidence (such as visual evidence and concentration of total TPH) to determine whether or not NAPL is likely to be present. If the presence of NAPL is deemed plausible the implications will be considered in the risk assessment.

3.2 Potential Harm to the Built Environment

Land contamination can pose risks to buildings, building materials and services (BBM&S) in a number of ways. Volatile contaminants and gases can accumulate and cause explosion or fire. Foundations and buried services can be damaged by corrosive substances and contaminants such as steel slags can create unstable ground conditions through expansion causing structural damage.

PBA use the following primary guidance to assess the significance of soil chemistry with respect to its potential to harm the built environment.

i) Approved Document C - Site Preparation and Resistance to Contaminants and Moisture. (DCLG, 2013);
ii) Concrete in aggressive ground SD1 (BRE 2005);
iii) Guidance for the selection of water supply pipes to be used in brownfield sites (UKWIR 2011);
iv) Protocols published by agreement between Water UK and the Home Builders Federation providing supplementary guidance which includes the Risk Assessment for Water Pipes (the 'RA') (Water UK 2014).
v) Performance of Building Materials in Contaminated Land report BR255 (BRE 1994).
vi) Risks of Contaminated Land to Buildings, Building Materials and Services. A Literature Review - Technical Report P331 (EA, 2000).
vii) Guidance on assessing and managing risks to buildings from land contamination - Technical Report P5 035/TR/01 (EA, 2001).

3.3 Potential to Harm Ecosystems, Animals, Crops etc

The criteria routinely used by PBA as Tier 2 screening values to assess the potential of soil chemistry to harm ecosystems are taken from the following guidance and are summarised in Table 5.

i) Derivation and Use of Soil Screening Values for assessing ecological risks. Report – ShARE id26 by the Environment Agency, Bristol (EA, 2017a);

ii) The Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing (ICRCL 70/90, 1990);

iii) Sewage sludge on farmland: code of practice for England, Wales and Northern Ireland (Defra, 2017a); and

iv) BS 3882:2015 Specification for topsoil and requirements for use (BSI, 2015).

Unless stated in the report the assessment is solely for phytotoxic parameters and additional assessment is required to determine suitability as a growing medium.

4 Criteria for Assessing Liquid Results

4.1 Potential Harm to Human Health via Ingestion

The Tier 2 water screening values routinely adopted by PBA for assessing the potential for harm to human health via ingestion (presented as Table 6) are taken from Statutory Instrument (S.I.) The Water Supply (Water Quality) Regulations (S.I. 2016/614).

It should be noted that some of the prescribed concentrations listed in the Water Supply Regulations have been set for reasons other than their potential to cause harm to human health. The concentrations of iron and manganese are controlled because they may taint potable water with an undesirable taste, odour or colour or may potentially deposit precipitates in water supply pipes.

4.2 Potential Harm to Human Health via Inhalation of Vapours

The Tier 2 water screening values adopted by PBA for assessing the potential for chronic human health risk from the inhalation of vapours from volatile contaminants in groundwater are presented in Table 7. These generic assessment criteria have been taken from a report published by the Society of Brownfield Risk Assessment (SoBRA) (SoBRA, 2017). The methodology adopted in their generation is considered compatable with the UK approach to deriving GAC and adopts a precautionary approach. As with all published GAC the suitability for use on the site being assessed has to be decided by the assessor based on a thorough understanding of the methodology and assumptions used in their derivation. Note, that the SoBRA groundwater vapour GAC are not intended for assessing risks to ground workers from short-term exposure.

Note that Table 7 shows the theoretical maximum aqueous solubility for each contaminant and indicates the GAC that exceed solubility. Measured concentrations in excess of solubility may be an indication that NAPL is present. As for the assessment of soils, if the presence of NAPL is deemed plausible the implications will be considered in the risk assessment.

4.3 Potential to Harm Controlled Waters

When assessing ground condition data and the potential to harm Controlled Waters PBA uses the approach presented in the groundwater protection position statements published 14.03.17 (EA, 2017b) which describe the Environment Agency's approach to managing and protecting groundwater. They update and replace Groundwater Protection: principles and practice (GP3). Controlled Waters are rivers, estuaries, coastal waters, lakes and groundwaters. Water in the unsaturated zone is not groundwater but does come within the scope of the term "ground waters" as used and defined in the Water Resources Act 1991. It will continue to be a technical decision for the Environment Agency to determine what is groundwater in certain circumstances for the purposes of the Regulations. As discussed in "PBA Methodology for Assessment of Land Contamination" perched water is not considered a receptor in PBA assessments.

The EU Water Framework Directive (WFD) 2000/60/EC provides for the protection of sub-surface, surface, coastal and territorial waters through a framework of river basin management.

The EU Updated Water Framework Standards Directive 2014/101/EU amended the EU WFD to update the international standards therein; it entered into force on 20 November 2014 with the requirement for its provisions to be transposed in Member State law by 20 May 2016.

Member States are required under the EU WFD to update their river basin management plans every six years. The first river basin management plans for England and Wales, Scotland and Northern Ireland were published in December 2009, and these were updated in 2015.

Other EU Directives in the European water management framework include:

• the EU Priority Substances Directive 2013/39/EU;

• EU Groundwater Pollutants Threshold Values Directive 2014/80/EU amending the EU Groundwater Daughter Directive (GWDD) 2006/118/EC; and

• the EU Biological Monitoring Directive 2014/101/EU.

The Priority Substances Directive set environmental quality standards (EQS) for the substances in surface waters (river, lake, transitional and coastal) and confirmed their designation as priority or priority hazardous substances (PS), the latter being a subset of particular concern. Environmental Quality Standards for PS are determined at the European level and apply to all Member States. Member States identify and develop standards for 'Specific

Pollutants'. Specific Pollutants (SP) are defined as substances that can have a harmful effect on biological quality.

The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 were issued by Defra to the Environment Agency as an associated document of the Water Environment (WFD) (England and Wales) Regulations 2015 (S.I. 2015/1623) and provide directions for the classification of surface water and groundwater bodies. Schedule 3 parts 2 and 3 relate to surface water standards for specific pollutants in fresh or salt water bodies and priority substances in inland (rivers, lakes and related modified/artificial bodies) or other surface waters respectively. Although Schedule 5 presents threshold values for groundwater the Direction specifically excludes their use as part of site specific investigations.

Table 6 presents the criteria routinely used by PBA as Tier 2 screening values. This table only presents a selection of the more commonly analysed parameters and the source documents should be consulted for other chemicals. For screening groundwater the criteria selected are the standards for surface water and/or human consumption as appropriate together with the following:-

For a **hazardous substance** PBA adopts the approach that, if the concentration in a discharge to groundwater is less than the Minimum Reporting Value (MRV), the input is regarded as automatically meeting the Article 2 (b) 'de-minimus' requirement of exemption 6 (3) (b) of the GWDD. PBA has selected hazardous substances from the latest list published by the Joint Agencies Groundwater Directive Advisory Group (JAGDAG, 2018). MRV is the lowest concentration of a substance that can be routinely determined with a known degree of confidence, and may not be equivalent to limit of detection. MRVs have been identified from DEFRA's guidance on Hazardous Substances to Groundwater: Minimum Reporting Values (DEFRA, 2017b), and are shown in Table 6.

Note that for land contamination assessments, where hazardous substances have already entered groundwater, remediation targets would typically be based on achieving appropriate water quality standards (e.g. drinking water standard or EQS) at a compliance point rather than an MRV. For this reason, when assessing measured groundwater or soil leachate concentrations, the values for human consumption, fresh water and salt water shown in Table 6 (whichever is appropriate for the context of the site) will be used as the Tier 2 assessment criteria rather than MRV. For hazardous substances with no water quality standard the laboratory method detection limit will be used as the assessment criteria.

For **non-hazardous substances** the GWDD requires that inputs be limited to avoid deterioration. UKTAG guidance equates deterioration with pollution. Non-hazardous substances are all substances not classified as hazardous. For PBA assessments the values for human consumption, fresh water and salt water shown in Table 6 (whichever is appropriate for the context of the site) are used as the assessment criteria for non hazardous substances.

Note on Copper, Lead, Manganese, Nickel and Zinc

$EQS_{bioavailable}$ have been developed for UK Specific Pollutants copper, zinc and manganese and the EU priority substances lead and nickel. An EQS is the concentration of a chemical in the environment below which there is not expected to be an adverse effect on the specific endpoint being considered, e.g. the protection of aquatic life.

It is very difficult to measure the bioavailable concentration of a metal directly. The UK has developed simplified Metal Bioavailability Assessment Tool (M-BAT) for copper, zinc, nickel and manganese which uses local water chemistry data, specifically pH, dissolved organic carbon (DOC) (mg L-1) and Calcium (Ca) (mg L-1).

Where the recorded total dissolved concentration exceeds the screening criteria for these parameters ($EQS_{bioavailable}$) further assessment will be undertaken using the tools downloaded from http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat

The models calculate a risk characterisation ratio (RCR) and where this is greater than 1 this indicates the bioavailable concentration is above the EQS and the parameter is then identified as a potential hazard. The report will discuss this identified hazard noting that the pH, calcium and, in particular, the dissolved organic carbon (DOC) in groundwater may be quite different to the receiving water (e.g. due to the presence to leaf litter or organic sediments dissolving in the water).

5 Criteria for Assessing Gas Results

PBA use the following primary guidance on gas monitoring methods and strategy, the assessment of risk posed by soil gases (including Volatile Organic Compounds (VOCs)) and mitigation measures/risk reduction during site development.

i) BS 8576:2013 – Guidance on Ground Gas Investigations: Permanent gases and Volatile Organic Compounds (VOCs) (BSI, 2013);

ii) TB18 Continuous Ground-Gas Monitoring and the Lines of Evidence Approach to Risk Assessment CL:AIRE Technical Bulletin TB18 (CL:AIRE 2019)

iii) RB17 A pragmatic approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin

RB17 (CL:AIRE, 2012);

iv) The VOCs Handbook. C682 (CIRIA, 2009).

v) Assessing risks posed by hazardous gases to buildings C665 (CIRIA, 2007);

vi) Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present. (NHBC, 2007); and

vii) BS BS 8485:2015+A1:2019- Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (BSI, 2019).

Gas and borehole flow data are used to obtain the gas screening value (GSV) for methane and carbon dioxide. The GSV is used to establish the characteristic situation and to make recommendations for gas protection measures for buildings if required.

Radon

PBA use the following primary guidance to assess the significance of the radon content of soil gas.

i) Radon: guidance on protective measures for new dwellings. Report BR211 (BRE, 2015); and

ii) Indicative Atlas of Radon in England and Wales (HPA & BGS, 2007).

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Table 1: Category 4 Screening Levels (C4SL) – Table taken from SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document (Department for Environment, Food and Rural Affairs December 2014)

	Residential (with home-grown produce)	Residential (without home-grown produce)	Allotments	Commercial	Public Open Space 1	Public Open Space 2
Arsenic	37	40	49	640	79	170
Benzene	0.87	3.3	0.18	98	140	230
Benzo(a)pyrene	5.0	5.3	5.7	77	10	21
Cadmium	22	150	3.9	410	220	880
Chromium VI	21	21	170	49	21	250
Lead	200	310	80	2300	630	1300

Units mg/kg dry weight
Public Open Space 1 – for grassed area adjacent to residential housing
Public Open Space 2 - Park Type Public Open Space Scenario
Based on a sandy loam with 6% soil organic matter (SOM) - Note that, with the exception of benzene, these C4SL are not SOM dependent

Table 2: Suitable 4 Use Levels (S4UL) - units are mg/kg Dry Weight

Determinand	Allotment	RwHP	RwoHP	Commercial/ Industrial	POSresi	POSpark
Metals						
Arsenic (**Inorganic**)[a, b, c]	43	37	40	640	79	170
Beryllium [a, b, d, e]	35	1.7	1.7	12	2.2	63
Boron [a, b, d]	45	290	11000	240000	21000	46000
Cadmium (**pH6-8**) [a, b, d, f]	1.9	11	85	190	120	560
Chromium (trivalent) [a, b, d, g]	18000	910	910	8600	1500	33000
Chromium (hexavalent) [a, b, c]	1.8[h]	6[i]	6[i]	33[i]	7.7[i]	220[i]
Copper [a, b, c]	520	2400	7100	68000	12000	44000
Mercury (elemental) [a, b, c, j]	21	1.2	1.2	58[vap] (25.8)	16	30[vap] (25.8)
Mercury (inorganic) [a, b, c]	19	40	56	1100	120	240
Methylmercury [a, b, c]	6	11	15	320	40	68
Nickel [a, b, c]	53[k]	130[e]	180[e]	980[e]	230[e]	800[k]
Selenium [a, b, c]	88	250	430	12000	1100	1800
Vanadium [a, b, c, i, j]	91	410	1200	9000	2000	5000
Zinc [a, b, c]	620	3700	40000	730000	81000	170000
BTEX Compounds (SOM 1%/ 2.5%/ 6%)						
Benzene [a, b, l, m]	0.017/0.034/ 0.075	0.087/0.17/ 0.37	0.38/0.7/1.4	27 / 47 / 90	72 / 72 / 73	90 / 100 / 110
Toluene [a, b, l, m]	22 / 51 / 120	130 / 290 / 660	880[vap] (869) /1900/3900	56000[vap] (869) / 110000[vap] (1920)/ 180000[vap] (4360)	56000 / 56000 / 56000	87000[vap](869)/ 95000[vap](1920)/ 100000[vap](4360)
Ethylbenzene [a, b, l, m]	16 / 39 / 91	47 / 110 / 260	83 / 190 / 440	5700[vap] (518) / 13000[vap] (1220) / 27000[vap] (2840)	24000 / 24000 / 25000	17000[vap] (518) / 22000[vap](1220) / 27000[vap] (2840)
O – Xylene [a, b, l, m, n]	28 / 67 / 160	60 / 140 / 330	88 / 210 / 480	6600[sol] (478) / 15000[sol] (1120) / 33000[sol] (2620)	41000 / 42000 / 43000	17000[sol] (478) / 24000[sol] (1120) / 33000[sol] (2620)
M – Xylene [a, b, l, m, n]	31 / 74 / 170	59 / 140 / 320	82 / 190 / 450	6200[vap] (625) / 14000[vap] (1470) / 31000[vap] (3460)	41000 / 42000 / 43000	17000[vap] (625) / 24000[vap](1470) / 32000[vap] (3460)
P – Xylene [a, b, l, m, n]	29 / 69 / 160	56 / 130 / 310	79 / 180 / 430	5900[sol] (576) / 14000[sol] (1350) / 30000[sol] (3170)	41000 / 42000 / 43000	17000[sol] (576) / 23000[sol] (1350) / 31000[sol] (3170)
Total xylenes [t]	28 / 67 / 160	56 / 130 / 310	79 / 180 / 430	5900[sol] (576) / 14000[sol] (1350) / 30000[sol] (3170)	41000 / 42000 / 43000	17000[sol] (576) / 23000[sol] (1350) / 31000[sol] (3170)
Polycyclic Aromatic Hydrocarbons (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
Acenaphthene	34 / 85 / 200	210 / 510 / 1100	3000[sol](57.0)/ 4700[sol] (141)/ 6000[sol] (336)	84000[sol] (57.0)/ 97000[sol] (141)/ 100000	15000 / 15000 / 15000	29000/ 30000/ 30000
Acenaphthylene	28 / 69 / 160	170 / 420 / 920	2900[sol](86.1)/ 4600[sol] (212)/ 6000[sol] (506)	83000[sol] (86.1)/ 97000[sol] (212)/ 100000	15000 / 15000 / 15000	29000 / 30000 / 30000
Anthracene	380 / 950 / 2200	2400 / 5400 / 11000	31000[sol](1.17) /35000/ 37000	520000/ 540000/ 540000	74000 / 74000 / 74000	150000 / 150000 / 150000
Benzo(a)anthracene	2.9 / 6.5 / 13	7.2 / 11 / 13	11 / 14 / 15	170 / 170 / 180	29 / 29 / 29	49 / 56 / 62
Benzo(a)pyrene (Bap) [u]	0.97 / 2.0 / 3.5	2.2 / 2.7 / 3.0	3.2 / 3.2 / 3.2	35 / 35 / 36	5.7 / 5.7 / 5.7	11 / 12 / 13
Benzo(b)fluoranthene	0.99 / 2.1 / 3.9	2.6 / 3.3 / 3.7	3.9 / 4.0 / 4.0	44 / 44 / 45	7.1 / 7.2 / 7.2	13 / 15 / 16
Benzo(g,h,i)perylene	290 / 470 / 640	320 / 340 / 350	360 / 360 / 360	3900 / 4000 / 4000	640 / 640 / 640	1400 / 1500 / 1600
Benzo(k)fluoranthene	37 / 75 / 130	77 / 93 / 100	110 / 110 / 110	1200 / 1200 /1200	190 / 190 / 190	370 / 410 / 440

Determinand	Allotment	RwHP	RwoHP	Commercial/ Industrial	POSresi	POSpark
Chrysene	4.1 / 9.4 / 19	15 / 22 / 27	30 / 31 / 32	350 / 350 / 350	57 / 57 / 57	93 / 110 / 120
Dibenzo(ah)anthracene	0.14 / 0.27 / 0.43	0.24 / 0.28 / 0.3	0.31 / 0.32 / 0.32	3.5 / 3.6 / 3.6	0.57 / 0.57 / 0.58	1.1 / 1.3 / 1.4
Fluoranthene	52 / 130 / 290	280 / 560 / 890	1500 / 1600 / 1600	23000 / 23000 / 23000	3100 / 3100 / 3100	6300 / 6300 / 6400
Fluorene	27 / 67 / 160	170 / 400 / 860	2800^{sol} (30.9) /3800^{sol} (76.5) /4500^{sol} (183)	63000^{sol} (30.9) / 68000 / 71000	9900 / 9900 / 9900	20000 / 20000 / 20000
Indeno(1,2,3-cd)pyrene	9.5 / 21 / 39	27 / 36 / 41	45 / 46 / 46	500 / 510 / 510	82 / 82 / 82	150 / 170 / 180
Naphthalene [q]	4.1 / 10 / 24	2.3 / 5.6 / 13	2.3 / 5.6 / 13	190^{sol} (76.4) / 460^{sol} (183) / 1100^{sol} (432)	4900/ 4900/ 4900	1200^{sol} (76.4) / 1900^{sol} (183) / 3000
Phenanthrene	15 / 38 / 90	95 / 220 / 440	1300^{sol}(36.0) / 1500 / 1500	22000 / 22000 / 23000	3100 / 3100 / 3100	6200 / 6200 / 6300
Pyrene	110 / 270 / 620	620 / 1200 / 2000	3700 / 3800 / 3800	54000 / 54000 / 54000	7400 / 7400 / 7400	15000 / 15000 / 15000
Coal Tar (Bap as surrogate marker) [u]	0.32 / 0.67 / 1.2	0.79 / 0.98 / 1.1	1.2 / 1.2 / 1.2	15 / 15 / 15	2.2 / 2.2 / 2.2	4.4 / 4.7 / 4.8
Explosives [a, b, l, p]						
2, 4, 6 Trinitrotoluene	0.24 / 0.58 / 1.40	1.6 / 3.7 / 8.0	65 / 66 / 66	1000 / 1000 / 1000	130 / 130 / 130	260 / 270 / 270
RDX (Royal Demolition Explosive $C_3H_6N_6O_6$)	17 / 38 / 85	120 / 250 / 540	13000 / 13000 / 13000	210000 / 210000 / 210000	26000 / 26000 / 27000	49000^{sol} (18.7) / 51000 / 53000
HMX (High Melting Explosive $C_4H_8N_8O_8$)	0.86 / 1.9 / 3.9	5.7 / 13 / 26	6700 / 6700 / 6700	110000 / 110000 / 110000	13000 / 13000 / 13000	23000^{vap} (0.35) /23000^{vap} (0.39) /24000^{vap} (0.48)
Petroleum Hydrocarbons (SOM 1%/ 2.5%/ 6%) [a, b, l, m]						
Aliphatic EC 5-6	730 / 1700 / 3900	42 / 78 / 160	42 / 78 / 160	3200^{sol} (304) / 5900^{sol} (558) / 12000^{sol} (1150)	570000^{sol}(304) 590000 / 600000	95000^{sol} (304) / 130000^{sol} (558)/ 180000^{sol}(1150)
Aliphatic EC >6-8	2300 / 5600 / 13000	100 / 230 / 530	100 / 230 / 530	7800^{sol} (144) / 17000^{sol} (322) / 40000^{sol} (736)	600000 / 610000 / 620000	150000^{sol} (144) 220000^{sol} (322)/ 320000^{sol} (736)
Aliphatic EC >8-10	320 / 770 / 1700	27 / 65 / 150	27 / 65 / 150	2000^{sol} (78) / 4800^{vap} (190) / 11000^{vap} (451)	13000 / 13000 / 13000	14000^{sol} (78) / 18000^{vap} (190) / 21000^{vap} (451)
Aliphatic EC >10-12	2200 / 4400 / 7300	130v^{ap} (48) / 330^{vap} (118) / 760^{vap} (283)	130v^{ap} (48) / 330^{vap} (118) / 770^{vap} (283)	9700^{sol} (48) / 23000^{vap} (118) / 47000^{vap} (283)	13000 / 13000 / 13000	21000^{sol} (48) / 23000^{vap} (118) / 24000^{vap} (283)
Aliphatic EC >12-16	11000 / 13000 / 13000	1100^{sol} (24) / 2400^{sol} (59) / 4300^{sol} (142)	1100^{sol} (24) / 2400^{sol} (59) / 4400^{sol} (142)	59000^{sol} (24) / 82000^{sol} (59) / 90000^{sol} (142)	13000 / 13000 / 13000	25000^{sol} (24) / 25000^{sol} (59) / 26000^{sol} (142)
Aliphatic EC >16-35 [o]	260000 / 270000 / 270000	65000^{sol}(8.48 92000^{sol} (21) 110000	65000^{sol} (8.48 92000^{sol} (21) 110000	1600000 / 1700000 / 1800000	250000 / 250000 / 250000	450000 / 480000 / 490000
Aliphatic EC >35-44 [o]	260000 / 270000 / 270000	65000^{sol}(8.48 92000^{sol} (21) / 110000	65000^{sol}(8.48 92000^{sol} (21) 110000	1600000 / 1700000 / 1800000	250000 / 250000 / 250000	450000 / 480000 / 490000
Aromatic EC 5-7 (benzene)	13 / 27 / 57	70 / 140 / 300	370 / 690 / 1400	26000^{sol} (1220) / 46000^{sol} (2260) / 86000^{sol} (4710)	56000 / 56000 / 56000	76000^{sol} (1220) /84000^{sol}(2260)/ 92000^{sol} (4710)
Aromatic EC >7-8 (toluene)	22 / 51 / 120	130 / 290 / 660	860 / 1800 / 3900	56000^{vap} (869)/ 110000^{sol} (1920)/ 180000^{vap} (4360)	56000 / 56000 / 56000	87000^{vap}(869) / 95000^{sol} (1920)/ 100000^{vap}(4360)
Aromatic EC >8-10	8.6 / 21 / 51	34 / 83 / 190	47 / 110 / 270	3500^{vap} (613) / 8100^{vap} (1500) / 17000^{vap} (3580)	5000 / 5000 / 5000	7200^{vap}(613) / 8500^{vap} (1500) / 9300^{vap} (3580)
Aromatic EC >10-12	13 / 31 / 74	74 / 180 / 380	250 / 590 / 1200	16000^{sol} (364) / 28000^{sol} (899) / 34000^{sol} (2150)	5000 / 5000 / 5000	9200^{sol} (364) / 9700^{sol} (899) / 10000
Aromatic EC >12-16	23 / 57 / 130	140 / 330 / 660	1800 / 2300^{sol} (419) / 2500	36000^{sol} (169) / 37000 / 38000	5100 / 5100 / 5000	10000 / 10000 / 10000
Aromatic EC >16-21 [o]	46 / 110 / 260	260 / 540 / 930	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7600 / 7700 / 7800
Aromatic EC >21-35 [o]	370 / 820 / 1600	1100 / 1500 / 1700	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Aromatic EC >35-44 [o]	370 / 820 / 1600	1100 / 1500 / 1700	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Aliphatic+Aromatic EC >44-70 [o]	1200 / 2100 / 3000	1600 / 1800 / 1900	1900 / 1900 / 1900	28000 / 28000 / 28000	3800 / 3800 / 3800	7800 / 7800 / 7900
Chloroalkanes & Chloroalkenes (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
1,2-Dichloroethane	0.0046 / 0.0083 / 0.016	0.0071 / 0.011 / 0.019	0.0092 / 0.013 / 0.023	0.67 / 0.97 / 1.7	29 / 29 / 29	21 / 24 / 28
1,1,1 Trichloroethane (TCA)	48 / 110 / 240	8.8 / 18 / 39	9.0 / 18 / 40	660 / 1300 / 3000	140000 / 140000 / 140000	57000^{vap}(1425) 76000^{vap}(2915)/ 100000^{vap}(6392)
1,1,1,2 Tetrachloroethane	0.79 / 1.9 / 4.4	1.2 / 2.8 / 6.4	1.5 / 3.5 / 8.2	110 / 250 / 560	1400 / 1400 / 1400	1500 / 1800 / 2100
1,1,2,2 Tetrachloroethane	0.41 / 0.89 / 2.0	1.6 / 3.4 / 7.5	3.9 / 8.0 / 17	270 / 550 / 1100	1400 / 1400 / 1400	1800 / 2100 / 2300

Determinand	Allotment	R$_{W}$HP	R$_{WO}$HP	Commercial/ Industrial	POSresi	POSpark
Tetrachloroethene (PCE)	0.65 / 1.5 / 3.6	0.18 / 0.39 / 0.90	0.18 / 0.4 / 0.92	19 / 42 / 95	1400 / 1400 / 1400	810[sol](424)/1100[sol] (951)/1500
Tetrachloromethane (Carbon Tetrachloride)	0.45 / 1.0 / 2.4	0.026 / 0.056 / 0.13	0.026 / 0.056 / 0.13	2.9 / 6.3 / 14	890 / 920 / 950	190 / 270 / 400
Trichloroethene (TCE)	0.041 / 0.091 / 0.21	0.016 / 0.034 / 0.075	0.017 / 0.036 / 0.080	1.2 / 2.6 / 5.7	120 / 120 / 120	70 / 91 / 120
Trichloromethane (Chloroform)	0.42 / 0.83 / 1.7	0.91 / 1.7 / 3.4	1.2 / 2.1 / 4.2	99 / 170 / 350	2500 / 2500 / 2500	2600 / 2800 / 3100
Chloroethene (Vinyl Chloride)	0.00055/ 0.001/ 0.0018	0.00064 / 0.00087/ 0.0014	0.00077 / 0.001 / 0.0015	0.059 / 0.077 / 0.12	3.5 / 3.5 / 3.5	4.8 / 5.0 / 5.4
Phenol & Chlorophenols [a, b, l, p]						
Phenol	23 / 42 / 83	120 / 200 / 380	440 / 690 / 1200	440[dir] (26000) / 690[dir] (30000) / 1300[dir] (34000)	440[dir] (10000)/ 690[dir](10000) 1300[dir](10000)	440[dir] (7600) / 690[dir] (8300) / 1300[dir] (93000)
Chlorophenols (excluding PCP) [r]	0.13[s] / 0.3 / 0.7	0.87[s] / 2.0 / 4.5	94 / 150 / 210	3500 / 4000 / 4300	620 / 620 / 620	1100 / 1100 / 1100
Pentachlorophenol (PCP)	0.03 / 0.08 / 0.19	0.22/ 0.52 / 1.2	27[vap] (16.4) / 29 / 31	400 / 400 / 400	60 / 60 / 60	110 / 120 / 120
Other [a, b, l, p]						
Carbon Disulphide	4.8 / 10 / 23	0.14 / 0.29 / 0.62	0.14 / 0.29 / 0.62	11 / 22 / 47	11000 / 11000 / 12000	1300 / 1900 / 2700
Hexachlorobutadiene (HCBD)	0.25 / 0.61 / 1.4	0.29 / 0.7 / 1.6	0.32 / 0.78 / 1.8	31 / 66 / 120	25 / 25 / 25	48 / 50 / 51
Pesticides (SOM 1%/ 2.5%/ 6%) [a, b, l, p]						
Aldrin	3.2 / 6.1 / 9.6	5.7/ 6.6 /7.1	7.3 / 7.4 / 7.5	170 / 170 / 170	18 / 18 / 18	30 / 31 / 31
Atrazine	0.5 / 1.2 / 2.7	3.3 / 7.6 / 17.4	610 / 620 / 620	9300 / 9400 / 9400	1200 / 1200 / 1200	2300 / 2400 / 2400
Dichlorvos	0.0049 / 0.010 / 0.022	0.032 / 0.066 / 0.14	6.4 / 6.5 / 6.6	140 / 140 / 140	16 / 16 / 16	26 / 26 / 27
Dieldrin	0.17/0.41/0.96	0.97/ 2 / 3.5	7.0 / 7.3 / 7.4	170 / 170 / 170	18 / 18 / 18	30 / 30 / 31
Alpha - Endosulfan	1.2 / 2.9 / 6.8	7.4 / 18 / 41	160[vap] (0.003)/ 280[vap] (0.007)/ 410[vap] (0.016)	5600[vap] (0.003) / 7400[vap] (0.007) / 8400[vap] (0.016)	1200 / 1200 / 1200	2400 / 2400 / 2500
Beta - Endosulfan	1.1 / 2.7 / 6.4	7.0 / 17 / 39	190[vap](0.00007) /320[vap](0.0002) /440[vap](0.0004)	6300[vap](0.00007) /7800[vap](0.0002) / 8700	1200 / 1200 / 1200	2400 / 2400 / 2500
Alpha-Hexachlorocyclohexane	0.035/0.087/ 0.21	0.23/0.55 / 1.2	6.9 / 9.2 / 11	170 / 180 / 180	24 / 24 / 24	47 / 48 / 48
Beta - Hexachlorocyclohexane	0.013 / 0.032 / 0.077	0.085 / 0.2 / 0.46	3.7 / 3.8 / 3.8	65 / 65 / 65	8.1 / 8.1 / 8.1	15 / 15 / 16
Gamma – Hexachlorocyclohexane	0.0092 / 0.023 / 0.054	0.06 / 0.14 / 0.33	2.9 / 3.3 / 3.5	67 / 69 / 70	8.2 / 8.2 / 8.2	14 / 15 / 15
Chlorobenzenes [a, b, l, p]						
Chlorobenzene	5.9 / 14 / 32	0.46 / 1.0 / 2.4	0.46 / 1.0 / 2.4	56 / 130 / 290	11000 / 13000 / 14000	1300[sol](675)/ 2000[sol](1520)/ 2900
1,2-dichlorobenzene (1,2-DCB)	94 / 230 / 540	23 / 55 / 130	24 / 57 / 130	2000[sol] (571) / 4800[sol] (1370) / 11000[sol] (3240)	90000 / 95000 / 98000	24000[sol] (571) / 36000[sol] (1370) /51000[sol] (3240)
1,3-dichlorobenzene (1,3-DCB)	0.25 / 0.6 / 1.5	0.4 / 1.0 / 2.3	0.44 /1.1 / 2.5	30 / 73 / 170	300 / 300 / 300	390 / 440 / 470
1-4-dichlorobenzene (1,4-DCB)	15[i] / 37[i] / 88 [i]	61[q] / 150[q] /350 [q]	61[q] / 150[q] / 350[q]	4400[vap,q] (224) / 10000[vap,q] (540) / 25000[vap,q] (1280)	17000[i] / 17000[i] / 17000[i]	36000[vap,i] (224) / 36000[vap, i](540)/ 36000[vap,i](1280)
1,2,3-Trichlorobenzene	4.7 / 12 / 28	1.5 / 3.6 / 8.6	1.5 / 3.7 / 8.8	102 / 250 / 590	1800 / 1800 / 1800	770[vap] (134) / 1100[vap] (330) / 1600[vap] (789)
1,2,4- Trichlorobenzene	55 / 140 / 320	2.6 / 6.4 / 15	2.6 / 6.4 / 15	220 / 530 / 1300	15000 / 17000 / 19000	1700[vap] (318) / 2600[vap] (786) / 4000[vap] (1880)
1,3,5- Trichlorobenzene	4.7 / 12 / 28	0.33 / 0.81 / 1.9	0.33 / 0.81 / 1.9	23 / 55 / 130	1700 / 1700 / 1800	380[vap] (36.7) / 580[vap] (90.8) / 860[vap] (217)
1,2,3,4-Tetrachlorobenzene	4.4 / 11 / 26	15 / 36 / 78	24 / 56 / 120	1700[vap] (122) / 3080[vap] (304) / 4400[vap] (728)	830 / 830 / 830	1500[vap] (122) / 1600 / 1600
1,2,3,5- Tetrachlorobenzene	0.38 / 0.90 / 2.2	0.66 / 1.6 / 3.7	0.75 / 1.9 / 4.3	49[vap] (39.4) / 120[vap] (98.1) / 240[vap] (235)	78 / 79 / 79	110[vap] (39.4) / 120 / 130
1,2,4,5- Tetrachlorobenzene	0.06 / 0.16 / 0.37	0.33 / 0.77 / 1.6	0.73 / 1.7 / 3.5	42[sol] (19.7) / 72[sol] (49.1) / 96	13 / 13 / 13	25 / 26 / 26
Pentachlorobenzene (P$_E$CB)	1.2 / 3.1 / 7.0	5.8 / 12 / 22	19 / 30 / 38	640[sol] (43.0) / 770[sol] (107) / 830	100 / 100 / 100	190 / 190 / 190
Hexachlorobenzene (HCB)	0.47 / 1.1 / 2.5	1.8[vap] (0.20) / 3.3[vap] (0.5) / 4.9	4.1[vap] (0.20) / 5.7[vap] (0.5) / 6.7[vap] (1.2)	110[vap] (0.20) / 120 / 120	16 / 16 / 16	30 / 30 / 30

R$_{W}$HP Residential with homegrown produce
R$_{WO}$HP Residential without homegrown produce
POSresi public open spaces near residential housing
POSpark public open space for recreational use but not dedicated sports pitches

SOM Soil Organic Matter – ***the S4UL for all organic compounds will vary according to SOM***
a Based on a sandy loam soil as defined in SR3 (Environment Agency, 2009b) and 6% soil organic matter (SOM)
b Figures rounded to two significant figures
c Based only on a comparison of oral and dermal soil exposure with oral Index Dose
d The background ADE is limited to being no larger than the contribution from the relevant soil ADE
e Based on comparison of inhalation exposure with inhalation TDI only
f Based on a lifetime exposure via the oral, dermal and inhalation pathways
g Based on localised effects comparing inhalation exposure with inhalation ID only
h Based on comparison of inhalation exposure with inhalation ID
i Based on comparison of oral and dermal exposure with oral TDI
j Based on comparison of oral, dermal and inhalation exposure with inhalation TDI
k Based on comparison of all exposure pathways with oral TDI
l S4ULs assume that free phase contamination is not present
m S4ULs based on a sub-surface soil to indoor air correction factor of 10
n The HCV applied is based on the intake of total Xylene and therefore exposure should not consider an isomer in isolation
o Oral, dermal and inhalation exposure compared with oral HCV
p S4ULs based on a sub-surface soil to indoor air correction factor of 1
q Based on a comparison of inhalation exposure with the inhalation TDI for localised effects
r Based on 2,4-dichlorophenol unless otherwise stated
s Based on 2,3,4,6-tetrachlorophenol
t Based on lowest GAC for all three xylene isomers
u. Measured concentrations of benzo(a)pyrene should be compaed to the S4UL for benzo(a)pyrene as a single compound and to the S4UL for benzo(a)pyrene as a surrogare marker of genotoxic PAHs.
vap S4UL presented exceeded the vapour saturation limit, which is presented in brackets
sol S4UL presented exceeds the solubility saturation limit, which is presented in brackets
dir S4ULs based on a threshold protective of direct skin contact, guideline in brackets based on the health effects following long term exposure provided for illustration only

Table 3: Soil Guideline Values (SGVs) for dioxins, furans and dioxin like PCBs

Determinand	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Allotments	Commercial
Sum of PCDDs, PCDFs and dioxin-like PCBs	0.008	0.008	0.008	0.24

Units are mg/kg Dry Weight

Table 4: EIC/AGS/CL:AIRE Generic Assessment Criteria (GAC)

Determinand	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Allotments	Commercial	Soil Saturation Concentration
Metals					
Antimony	ND	550	ND	7500	NA
Barium	ND	1300	ND	22000	NA
Molybdenum	ND	670	ND	17000	NA
Organics (SOM 1%/ 2.5%/ 6%)					
1,1,2 Trichloroethane	0.6 / 1.2 / 2.7	0.88 / 1.8 / 3.9	0.28 / 0.61 / 1.4	94 / 190 / 400	4030 / 8210 / 18000
1,1-Dichloroethane	2.4 / 3.9 / 7.4	2.5 / 4.1 / 7.7	9.2 / 17 / 35	280 / 450 / 850	1830 / 2960 / 5600
1,1-Dichloroethene	0.23 / 0.4 / 0.82	0.23 / 0.41 / 0.82	2.8 / 5.6 / 12	26 / 46 / 92	2230 / 3940 / 7940
1,2,4-Trimethylbenzene	0.35 / 0.85 / 2	0.41 / 0.99 / 2.3	0.38 / 0.93 / 2.2	42 / 99 / 220	557 / 1360 / 3250
1,2-Dichloropropane	0.024 / 0.042 / 0.084	0.024 / 0.042 / 0.085	0.62 / 1.2 / 2.6	3.3 / 5.9 / 12	1190 / 2110 / 4240
2,4-Dimethylphenol	19 / 43 / 97	210 / 410 / 730	3.1 / 7.2 / 17	16000 / 24000 / 30000	1380 / 3140 / 7240
2,4-Dinitrotoluene	1.5 / 3.2 / 7.2	170 / 170 / 170	0.22 / 0.49 / 1.1	3700 / 3700 / 3800	141 / 299 / 669
2,6-Dinitrotoluene	0.78 / 1.7 / 3.9	78 / 84 / 87	0.12 / 0.27 / 0.61	1900 / 1900 / 1900	287 / 622 / 1400
2-Chloronaphthalene	3.7 / 9.2 / 22	3.8 / 9.3 / 22	40 / 98 / 230	390 / 960 / 2200	114 / 280 / 669
Biphenyl	66 / 160 / 360	220 / 500 / 980	14 / 35 / 83	18000 / 33000 / 48000	34.4 / 84.3 / 201
Bis (2-ethylhexyl) phthalate	280 / 610 / 1100	2700 / 2800 / 2800	47 / 120 / 280	85000 / 86000 / 86000	8.68 / 21.6 / 51.7
Bromobenzene	0.87 / 2 / 4.7	0.91 / 2.1 / 4.9	3.2 / 7.6 / 18	97 / 220 / 520	853 / 1970 / 4580
Bromodichloromethane	0.016 / 0.03 / 0.061	0.019 / 0.034 / 0.07	0.016 / 0.032 / 0.068	2.1 / 3.7 / 7.6	1790 / 3220 / 6570
Bromoform	2.8 / 5.9 / 13	5.2 / 11 / 23	0.95 / 2.1 / 4.6	760 / 1500 / 3100	2690 / 5480 / 12000
Butyl benzyl phthalate	1400 / 3300 / 7200	42000 / 44000 / 44000	220 / 550 / 1300	940000 / 940000 / 950000	26.3 / 64.7 / 154
Chloroethane	8.3 / 11 / 18	8.4 / 11 / 18	110 / 200 / 380	960 / 1300 / 2100	2610 / 3540 / 5710
Chloromethane	0.0083 / 0.0098 / 0.013	0.0085 / 0.0099 / 0.013	0.066 / 0.13 / 0.23	1 / 1.2 / 1.6	1910 / 2240 / 2990
Cis 1,2 Dichloroethene	0.11 / 0.19 / 0.37	0.12 / 0.2 / 0.39	0.26 / 0.5 / 1	14 / 24 / 47	3940 / 6610 / 12900
Dichloromethane	0.58 / 0.98 / 1.7	2.1 / 2.8 / 4.5	0.1 / 0.19 / 0.34	270 / 360 / 560	7270 / 9680 / 15300
Diethyl Phthalate	120 / 260 / 570	1800 / 3500 / 6300	19 / 41 / 94	150000 / 220000 / 290000	13.7 / 29.1 / 65
Di-n-butyl phthalate	13 / 31 / 67	450 / 450 / 450	2 / 5 / 12	15000 / 15000 / 15000	4.65 / 11.4 / 27.3
Di-n-octyl phthalate	2300 / 2800 / 3100	3400 / 3400 / 3400	940 / 2100 / 3900	89000 / 89000 / 89000	32.6 / 81.5 / 196
Hexachloroethane	0.2 / 0.48 / 1.1	0.22 / 0.54 / 1.3	0.27 / 0.67 / 1.6	22 / 53 / 120	8.17 / 20.1 / 48.1
Isopropylbenzene	11 / 27 / 64	12 / 28 / 67	32 / 79 / 190	1400 / 3300 / 7700	390 / 950 / 2250

Determinand	Residential with consumption of homegrown produce	Residential without consumption of homegrown produce	Allotments	Commercial	Soil Saturation Concentration
Methyl tert-butyl ther	49 / 84 / 160	73 / 120 / 220	23 / 44 / 90	7900 / 13000 / 24000	20400 / 33100 / 62700
Propylbenzene	34 / 82 / 190	40 / 97 / 230	34 / 83 / 200	4100 / 9700 / 21000	402 / 981 / 2330
Styrene	8.1 / 19 / 43	35 / 78 / 170	1.6 / 3.7 / 8.7	3300 / 6500 / 11000	626 / 1440 / 3350
Total Cresols (2-, 3- and 4-methylphenol)	80 / 180 / 400	3700 / 5400 / 6900	12 / 27 / 63	160000 / 180000 / 180000	15000 / 32500 / 73300
Trans 1,2 Dichloroethene	0.19 / 0.34 / 0.7	0.19 / 0.35 / 0.71	0.93 / 1.9 / 4	22 / 40 / 81	3420 / 6170 / 12600
Tributyl tin oxide	0.25 / 0.59 / 1.3	1.4 / 3.1 / 5.7	0.042 / 0.1 / 0.24	130 / 180 / 200	41.3 / 101 / 241

Units are mg/kg Dry Weight

Table 5: Tier 2 Criteria for the Assessment of Soils – Protection of Ecological Systems/Animal and Crop Effect

Parameter	ICRCL 70/90 [a]		SSVs [b]	Code of Practice for Agricultural Use of Sewage Sludge [c]	BS 3882:2015 Specification for topsoil and requirements for use
	Maximum				Phytotoxic contaminants
	Livestock	Crop Growth			
	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW	mg/kgDW
Antimony			37		
Arsenic	500	1000		50	
Cadmium	30	50	0.6	3	
Chromium				400	
Cobalt			4.2		
Copper	500	250	35.1	80/ 100/ 135/ 200 [d]	<100/<135/<200 [e]
Fluoride	1000			500	
Lead	1000			300	
Mercury				1	
Molybdenum			5.1	4	
Nickel			28.2	50/ 60/ 75/ 110 [d]	<60/<75/<110 [e]
Selenium				3	
Silver			0.3		
Vanadium			2.0		
Zinc	3000	1000	35.6	200/200/200/300 [d]	<200/<200/<300 [e]
Benzo(a)pyrene			0.15		
Bis(2-ethylhexyl) phthalate			13		
Hexachlorobenzene			0.002		
Pentachlorobenzene					
Pentachlorophenol			0.6		
Perfluorooctanoic acid			0.022		
Perfluorooctane sulfonate			0.014		
Polychlorinated alkanes (medium chain)			11.9		
Tetrachloroethene					
Toluene					
Triclosan			0.13		
Tris(2-chloroethyl)phosphate			1.1		
Tris(2-chloro-1-methylethyl) phosphate			1.8		

a. Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) 70/90 Restoration and Aftercare of Metalliferous Mining Sites for Pasture and Grazing 1st edition 1990.
b. Soil screening values for assessing ecological risks, EA 2017a Report – ShARE id26
c. Maximum permissible concentration of potentially toxic elements for Arable land from the Sewage sludge in agriculture: code of practice.. There are also criteria for Grassland which are higher than for Arable.
d. Where four values are presented, concentrations are for soils with pH values 5.0-5.5/ 5.5-6.0/ 6.0-7.0/ >7.0 (and the soils contain more than 5% calcium carbonate)
e. Where three values are presented, concentrations are for soils with pH values <6.0/ 6.0-7.0/ >7.0

Table 6: Tier 2 Criteria for Screening Liquids

	Screening Concentration (mg/l)			
	Minimum Reporting Value	Human Consumption	Fresh Water/Inland	Salt Water/Other
Metals				
Arsenic SP	-	0.01	0.05 (2)	0.025 (2)
Boron	-	1	-	-
Cadmium PS	0.0001	0.005	≤0.00008, 0.00008, 0.00009, 0.00015, 0.00025 (14)	0.0002
Chromium (total)	-	0.05	-	-
Chromium (III) SP	-	-	0.0047	-
Chromium (VI) SP	-	-	0.0034	0.0006
Copper SP	-	2	0.001 bioavailable	0.00376 bioavailable
Iron SP	-	0.2	1	1
Lead PS	-	0.01	0.0012 bioavailable	0.0013 bioavailable
Mercury compounds PS	0.00001	0.001	0.00007 max	0.00007 max
Manganese SP	-	0.05	0.123 bioavailable	-
Nickel PS	-	0.02	0.004 bioavailable	0.0086 bioavailable
Selenium	-	0.01	-	-
Zinc SP	-	5(3)	0.0109bioavailable(13)	0.0068bioavailable (13)
Chlorinated Compounds				
C10-13 chloroalkanes PS short chain chlorinated paraffins	-	-	0.0004	0.0004
Dichloromethane PS	-	-	0.02	0.02
1,2-Dichloroethane PS	0.001	0.003	0.01	0.01
Trichloroethene PS	0.0001	0.01(5)	0.01	0.01
1,1,1-Trichloroethane	0.0001	-	-	-
1,1,2-Trichloroethane	0.0001	-	-	-
Trichloromethanes PS	-	0.1(1)	0.0025	0.0025
1, 2, 4-Trichlorobenzene	0.00001			
Tetrachloroethene PS	0.0001	0.01(5)	0.01	0.01
Tetrachloromethane PS	0.0001	0.003	0.012	0.012
Tetrachloroethane SP	-		0.140	
Vinyl chloride	-	0.0005	-	-
Trichlorobenzene (TCB) PS	-	-	0.0004	0.0004
Chloroform	0.0001			
Chloronitrotoluenes(CNT)(11)	0.001	-	-	-
Hexachlorobutadiene PS	0.000005	-	0.0006 max	0.0006 max
Hexachlorocyclohexanes (HCH) PS	0.000001	-	0.00002	0.000002
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	-	-	-	-
Acenaphthylene	-	-	-	-
Anthracene PS	-	-	0.0001	0.0001
Benzo(a)anthracene	-	-	-	-
Benzo(b)fluoranthene PS	-	0.0001 (10)	0.000017 max (12)	0.000017 max (12)
Benzo(a)pyrene PS	-	0.00001	0.00000017	0.00000017
Benzo(k)fluoranthene PS	-	0.0001 (10)	0.000017 max (12)	0.000017 max (12)
Benzo(g,h,i)perylene PS	-	0.0001 (10)	0.0000082 max (12)	0.00000082 max (12)
Indeno(1,2,3-cd)pyrene PS	-	0.0001 (10)	- (12)	- (12)
Chrysene		-	-	-
Dibenzo(a,h)anthracene		-	-	-
Fluoranthene PS	-	-	0.0000063	0.0000063
Fluorene	-	-	-	-
Phenanthrene	-	-	-	-

	Screening Concentration (mg/l)			
	Minimum Reporting Value	**Human Consumption**	**Fresh Water/Inland**	**Salt Water/Other**
Pyrene	-	-	-	-
Naphthalene PS	-	-	0.002	0.002
Polycyclic Aromatic Hydrocarbons		0.0001[10]		
Petroleum hydrocarbons				
Total petroleum hydrocarbons	-	0.01[3]	-	-
Benzene PS	0.001	0.001	0.01	0.008
Toluene SP	0.004	0.7[9]	0.074	0.074
Ethylbenzene	-	0.3[9]	-	-
Xylenes	0.003[4]	0.5[9]		
Methyl tert-butyl ether (MTBE)	-	0.015[7]	-	-
Pesticides and Herbicides				
Alachlor PS	-	-	0.0003	0.0003
Aldrin PS	0.000003	0.00003	0.00001[8]	0.000005[8]
Dieldrin PS	0.000003	0.00003		
Endrin PS	0.000003	0.0006[9]		
Isodrin	0.000003	-	-	-
2,4 dichlorophenol SP	0.0001	-	0.0042	0.00042
2,4 D ester SP	0.0001	-	0.0003	0.0003
op and pp DDT (each) PS		0.001[6]	0.000025 [6]	0.000025 [6]
op and pp DDE (each)				
op and pp TDE (each)				
Dimethoate SP	0.00001	-	0.00048	0.00048
Endosulfan PS	0.000005	-	0.000005	0.0000005
Hexachlorobenzene PS	0.000001		0.00005 max	0.00005 max
Permethrin SP		-	0.000001	0.0000002
Atrazine PS	0.00003	-	0.0006	0.0006
Simazine PS	0.00003	-	0.001	0.001
Linuron SP		-	0.0005	0.0005
Mecoprop SP		-	0.018	0.018
Trifluralin PS	0.00001	-	0.00003	0.00003
Total pesticides		0.0005		
Miscellaneous				
Ammoniacal nitrogen (as NH4+)	-	0.5	0.26 [16] 0.39 [17]	-
Ammoniacal nitrogen (as N)	-	0.39	0.2 [16] 0.3 [17]	-
Unionised Ammonia (NH3) SP	-	-	-	0.021
Chloride	-	250		
Chlorine SP			0.002	0.01 max
Cyanide SP (hydrogen cyanide)	-	0.05	0.001	0.001
Nitrate (as NO_3)	-	50	-	-
Nitrite (as NO_2)	-	0.1	-	-
Phenol SP	-	0.5 [3]	0.0077	0.0077
Pentachlorophenol PS	0.0001	-	0.0004	0.0004
PCBs (individual congeners)	0.000001	-	-	-
Sodium	-	200	-	-
Sulphate	-	250		-
Tributyl and triphenyl tin compounds (each) PS	0.000001	-	0.0000002	0.0000002
Di(2-ethylhexyl)-phthalate PS	-	-	0.0013	0.0013

Substances highlighted in yellow are hazardous substances, PS = Priority Substances, SP = Specific Pollutants, '-' screening concentration is not available, 'max' – maximum allowable concentration used where no annual average provided

Notes:

1. Concentration for trihalomethanes is the sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane.
2. Concentration is the dissolved fraction of a water sample obtained by filtration through a 0.45um filter.
3. Concentration is taken from Statutory Instrument 1989 No. 1147. The Water Supply (Water Quality) Regulations 1989, as amended.
4. Concentration for xylenes is 0.003mg/l each for o-xylene and m/p xylene.
5. Concentration is the Sum of TCE and PCE.
6. Concentration is for Total DDT. Para DDT on its own has a target concentration of 0.00001mg/l.

7. Concentration for MTBE is taken from Environment Agency guidance, dated 2006.
8. Concentration is the sum of aldrin, dieldrin, endrin.
9. Concentration is taken from WHO (2004) guidelines for drinking-water quality.
10. Sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, indeno(1,2,3-cd)pyrene
11. Concentration is for 2,6-CNT, 4,2-CNT, 4,3-CNT, 2,4-CNT, 2,5-CNT
12. BAP can be considered as a marker of the other PAHs for comparison with the annual average
13. Concentration plus ambient background concentration (dissolved)
14. For cadmium and its compounds the EQS depends on the hardness of the water (Class 1: < 40 mg CaCO3/l, Class 2: 40 to < 50 mg CaCO3/l, Class 3: 50 to < 100 mg CaCO3/l, Class 4: 100 to < 200 mg CaCO3/l and Class 5: ≥ 200 mg CaCO3/l).
15. Manufactured and used in industrial applications, such as flame retardants and plasticisers, as additives in metal working fluids, in sealants, paints, adhesives, textiles, leather fat and coatings. Persistent, bioaccumulate and toxic to aquatic life (carcinogen in rat studies). Candidate Persistent Organic Pollutant (POP).
16. Acceptable 90^{th} percentile concentration for a freshwater lake/river with "High" chemical quality standard and alkalinity (as mg/l CaCO3) < 50 mg/L or alkalinity < 200 mg/L where river elevation > 80 m above Ordnance Datum (mAOD). See the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for further details.
17. Acceptable 90^{th} percentile concentration for a freshwater lake/river with "High" chemical quality standard and alkalinity (as mg/l CaCO3) ≥ 50 mg/L where river elevation < 80 m mAOD or > 200 mg/l where river elevation > 80 mAOD. See the Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 for further details.

Table 7: Tier 2 Criteria for Screening Groundwater Vapour Generation Hazard

Chemical	CAS	GAC_{gwvap}(µg/l)[1,2]		Aqueous Solubility (µg/l)
		Residential	Commercial	
Petroleum Hydrocarbons				
1,2,4-Trimethylbenzene	95-63-6	24	2,200	559,000
Benzene [3]	71-43-2	210	20,000	1,780,000
Ethylbenzene [3]	100-41-4	10,000	*960,000 (sol)*	180,000
Isopropylbenzene	98-82-8	850	*86,000 (sol)*	56,000
Propylbenzene	103-65-1	2,700	*240,000 (sol)*	54,100
Styrene	100-42-5	8,800	*810,000 (sol)*	290,000
Toluene [3]	108-88-3	230,000	*21,000,000 (sol)*	590,000
TPH Aliphatic EC5-EC6 [3]		1,900	*190,000 (sol)*	35,900
TPH Aliphatic >EC6-EC8 [3]		1,500	*150,000 (sol)*	5,370
TPH Aliphatic >EC8-EC10 [3]		57	*5,700 (sol)*	427
TPH Aliphatic >EC10-EC12 [3]		37	*3,600 (sol)*	34
TPH Aromatic >EC5-EC7 [2,3]		210,000	*20,000,000 (sol)*	1,780,000
TPH Aromatic >EC7-EC8 [3]		220,000	*21,000,000 (sol)*	590,000
TPH Aromatic >EC8-EC10 [3]		1,900	*190,000 (sol)*	64,600
TPH Aromatic >EC10-EC12 [3]		6,800	*660,000 (sol)*	24,500
TPH Aromatic >EC12-EC16 [3]		39,000	*3,700,000 (sol)*	5,750
meta-Xylene [3,5]	108-38-3	9,500	*940,000 (sol)*	200,000
ortho-Xylene [3,5]	95-47-6	12,000	*1,100,000 (sol)*	173,000
para-Xylene [3,5]	106-42-3	9,900	*980,000 (sol)*	200,000
Polycyclic Aromatic Hydrocarbons (PAH)				
Acenaphthene	83-32-9	*170,000 (sol)*	*15,000,000 (sol)*	4,110
Acenaphthylene	208-96-8	*220,000 (sol)*	*20,000,000 (sol)*	7,950
Fluorene	86-73-7	*210,000 (sol)*	*18,000,000 (sol)*	1,860
Naphthalene	91-20-3	220	*23,000 (sol)*	19,000
Pesticides				
Aldrin	309-00-2	*47 (sol)*	*3,700 (sol)*	20
alpha-Endusulfan	959-98-8	*7,400 (sol)*	*590,000 (sol)*	530
beta-Endosulfan	33213-65-9	*7,500 (sol)*	*600,000 (sol)*	280
Halogenated Organics				
1,1,1,2-Tetrachloroethane	79-34-5	240	22,000	1,110,000

1,1,1-Trichloroethane	71-55-6	3,000	290,000	1,300,000
1,1,2,2-Tetrachloroethane	79-35-4	1,600	150,000	2,930,000
1,1,2-Trichloroethane	79-00-5	520	49,000	4,491,000
1,1-Dichloroethane	75-34-3	2,700	260,000	3,666,000
1,1-Dichloroethene	75-35-4	160	1,6000	3,100,000
1,2,3,4-Tetrachlorobenzene	634-66-2	240	*31,000 (sol)*	7,800
1,2,3,5-Tetrachlorobenzene	634-90-2	7.0	*600*	3,500
1,2,3-Trichlorobenzene	87-61-7	35	3,100	21,000
1,2,4,5-Tetrachlorobenzene	95-94-3	8.1	*700 (sol)*	600
1,2,4-Trichlorobenzene	120-82-1	68	7,200	41,400
1,2-Dichlorobenzene	95-50-1	2,000	*220,000 (sol)*	133,000
1,2-Dichloroethane	107-06-2	8.9	850	8,680,000
1,2-Dichloropropane	78-87-5	22	2,600	2,050,000
1,3,5-Trichlorobenzene	108-70-3	7.4	660	6,000
1,3-Dichlorobenzene	541-73-1	31	2,800	103,000
1,4-Dichlorobenzene	106-46-7	5,000	*460,000 (sol)*	51,200
Bromobenzene	108-86-1	220	20,000	388,040
Bromodichloromethane	75-27-4	17	1,600	3,000,000
Bromoform (Tribromomethane)	75-25-2	3,100	400,000	3,000,000
Chlorobenzene	108-90-7	98	15,000	387,000
Chloroethane	75-00-3	10,000	1,000,000	5,742,000
Chloroethene (Vinyl Chloride)	75-01-4	0.62	63	2,760,000
Chloromethane	74-87-3	14	1,400	5,350,000
cis-1,2-Dichloroethene	156-59-2	130	13,000	7,550,000
Dichloromethane	75-09-2	3,300	370,000	20,080,000
Hexachlorobenzene	118-74-1	*16 (sol)*	*1,400 (sol)*	10
Hexachlorobutadiene	87-68-3	1.7	230	4,800
Hexachloroethane	67-72-1	8.5	740	49,900
Pentachlorobenzene	608-93-5	140	*12,000 (sol)*	500
Tetrachloroethene	127-18-4	34	4,600	225,000
Tetrachloromethane (Carbon Tetrachloride)	56-23-5	5.3	770	846,000
trans-1,2-Dichloroethene	156-60-5	160	16,000	5,250,000
Trichloroethene	79-01-6	5.7	530	1,370,000
Trichloromethane (Chloroform)	67-66-3	790	85,000	8,950,000
Others (organic and inorganic)				
2-Chloronaphthalene	91-58-7	160	*14,000 (sol)*	11,700
Biphenyl (Lemonene)	92-52-4	*15,000 (sol)*	*1,300,000 (sol)*	4,060
Carbon Disulphide	75-15-0	56	5,600	2,100,000
Mercury, elemental	7439-97-6	1.1	*95 (sol)*	56
Methyl tertiary butyl ether (MTBE)	1634-04-4	83,000	7,800,000	48,000,000

Notes

1. GAC in *italics* with (sol) exceed aqueous solubility.
2. GAC rounded to two significant figures.
3. The GAC for these petroleum hydrocarbon contaminants have been calculated using a sub-surface soil to indoor air correction factor of 10 in line with the physical-chemical data sources.
4. The GAC for TPH fractions do not account for genotoxic mutagenic effects. Concentrations of TPH Aromatic >EC5-EC7 should therefore also be compared with the GAC for benzene to ensure that such effects are also assessed.
5. The Health Criteria Value used for each xylene isomer was for total xylene. If site specific additivity assessments are not completed, as a conservative measure the sum of isomer concentrations should be compared to the lowest xylene GAC (as is the case for soil GAC).

TABLES

Potential Contaminant		Measured Values			Upper Confidence Limit	Outlier Test		Critical Concentrations											
		Number of Tests	Minimum	Maximum		Critical Value	Number Exceedng	Residential w/produce		Exceeding No	UCL	Residential w/o produce		Exceeding No	UCL	Open Space residential		Exceeding No	UCL
General Industrial Contaminants																			
Arsenic	mg/kg	12	3.9	19	12	27	0	37	(1)	0	-	40	(1)	0	-	79	(1)	0	-
Cadmium	mg/kg	12	<0.10	0.60	0.16	0.50	1	22	(1)	0	-	150	(1)	0	-	220	(1)	0	-
Chromium (trivalent)	mg/kg	12	6.5	66	46	170	0	910	(2)	0	-	910	(2)	0	-	1500	(2)	0	-
Chromium (hexavalent)	mg/kg	12	<1.0	<1.0	-	-	0	6	(2)	0	-	6	(2)	0	-	7.7	(2)	0	-
Copper	mg/kg	12	7.2	41	25	57	0	2400	(2)	0	-	7100	(2)	0	-	12000	(2)	0	-
Lead	mg/kg	12	15	270	113	382	0	200	(1)	1	-	310	(1)	0	-	630	(1)	0	-
Mercury	mg/kg	12	<0.05	0.09	0.06	0.09	1	1.2	(2)	0	-	1.2	(2)	0	-	16	(2)	0	-
Nickel	mg/kg	12	6.2	54	35	117	0	130	(2)	0	-	180	(2)	0	-	230	(2)	0	-
Selenium	mg/kg	12	<0.50	0.60	-	0.57	1	250	(2)	0	-	430	(2)	0	-	1100	(2)	0	-
Zinc	mg/kg	12	28	100	83	170	0	3700	(2)	0	-	40000	(2)	0	-	81000	(2)	0	-
Sulphate	mg/l	12	54	380	219	571	0	-		-	-	-		-	-	-		-	-
TPH	mg/kg	12	<10	440	33	257	1	-		-	-	-		-	-	-		-	-
Total (of 16) PAHs	mg/kg	12	<1.6	30	12	39	0	-		-	-	-		-	-	-		-	-
Phenols	mg/kg	12	<0.30	0.90	0.61	1.20	0	120	(2)	0	-	440	(2)	0	-	440	(2)	0	-
Organic matter	%	12	0.20	3.00	0.78	2.90	1	-		-	-	-		-	-	-		-	-
pH Value	pH Units	12	8.2	11.4	9.9	12.0	0	-		-	-	-		-	-	-		-	-

Notes
(1) Denotes CL:AIRE C4SL for SOM of 1.0% (organic contaminants only)
(2) Denotes CIEH S4ULs© for SOM of 1.0% (organic contaminants only)
Full details of the assessment criteria are given in a guidance note included after the text of this report.
BTEX Denotes Benzene, Toluene, Ethylbenzene and Xylene
TPH Denotes Total Petroleum Hydrocarbons (Aliphatics & Aromatics >C5-C35)
PAH Denotes Polynuclear Aromatic Hydrocarbons
X Denotes Upper Confidence Limit (UCL) exceeding assessment value

Values below the Method Detection Limit taken to be 100% of the Method Detection Limit
Upper Confidence Limit is the concentration which the actual mean concentration will be below 19 times out of 20
Critical Value is the concentration above which values may be outliers of the data set as determined using the Grubbs Test.
Upper Confidence Limits are determined excluding values exceeeding Critical Value
Upper Confidence Limits and Critical Values have been determined assuming the data forms a normally distributed dataset.

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Client: City of Westminster

SUMMARY OF CHEMICAL ANALYSIS OF SOIL SAMPLES
[All Samples - All Data]

TORRIDON HOUSE CAR PARK, WESTMINSTER

Date	December 2019
Prepared by:	mdh
Checked by:	
Revision:	00
Table	**1a**

Potential Contaminant		Measured Values			Upper Confidence Limit	Outlier Test		Critical Concentrations											
		Number of Tests	Minimum	Maximum		Critical Value	Number Exceedng	Residential w/produce		Exceeding No	Exceeding UCL	Residential w/o produce		Exceeding No	Exceeding UCL	Open Space residential		Exceeding No	Exceeding UCL
Polyaromatic Hydrocarbons																			
Acenaphthene	mg/kg	12	<0.10	0.50	0.13	0.36	1	210	(2)	0	-	3000	(2)	0	-	15000	(2)	0	-
Acenaphthylene	mg/kg	12	<0.10	0.70	0.15	0.51	1	170	(2)	0	-	2900	(2)	0	-	15000	(2)	0	-
Anthracene	mg/kg	12	<0.10	1.30	0.25	1.10	1	2400	(2)	0	-	31000	(2)	0	-	74000	(2)	0	-
Benzo(a)anthracene	mg/kg	12	<0.10	2.10	0.90	3.40	0	7.2	(2)	0	-	11	(2)	0	-	29	(2)	0	-
Benzo(a)pyrene	mg/kg	12	<0.10	2.7	1.1	3.9	0	5	(1)	0	-	5.3	(1)	0	-	10	(1)	0	-
Benzo(b)fluoranthene	mg/kg	12	<0.10	2.50	0.98	3.70	0	2.6	(2)	0	-	3.9	(2)	0	-	7.1	(2)	0	-
Benzo(ghi)perylene	mg/kg	12	<0.10	1.70	0.68	2.20	0	320	(2)	0	-	360	(2)	0	-	640	(2)	0	-
Benzo(k)fluoranthene	mg/kg	12	<0.10	1.20	0.53	1.60	0	77	(2)	0	-	110	(2)	0	-	190	(2)	0	-
Chrysene	mg/kg	12	<0.10	2.10	0.81	2.90	0	15	(2)	0	-	30	(2)	0	-	57	(2)	0	-
Dibenzo(a,h)anthracene	mg/kg	12	<0.10	0.70	0.15	0.51	1	0.24	(2)	2	-	0.31	(2)	1	-	0.57	(2)	1	-
Fluoranthene	mg/kg	12	<0.10	4.5	1.7	8.5	0	280	(2)	0	-	1500	(2)	0	-	3100	(2)	0	-
Fluorene	mg/kg	12	<0.10	0.20	-	0.17	1	170	(2)	0	-	2800	(2)	0	-	9900	(2)	0	-
Indeno(1,2,3-cd)pyrene	mg/kg	12	<0.10	1.80	0.72	2.30	0	27.0	(2)	0	-	45.0	(2)	0	-	82.0	(2)	0	-
Naphthalene	mg/kg	12	<0.10	0.40	-	0.27	1	2.3	(2)	0	-	2.3	(2)	0	-	4900	(2)	0	-
Phenanthrene	mg/kg	12	<0.10	3.2	1.1	4.3	0	95	(2)	0	-	1300.0	(2)	0	-	3100.0	(2)	0	-
Pyrene	mg/kg	12	<0.10	5.2	1.9	8.8	0	620	(2)	0	-	3700	(2)	0	-	7400	(2)	0	-
PAH Total 16 EPA	mg/kg	12	<1.6	30	12	39	0	-		-	-	-		-	-	-		-	-

Notes
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Upper Confidence Limita and Critical Values have been determined assuming the data forms a normally distributed dataset.

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SUMMARY OF CHEMICAL ANALYSIS OF SOIL SAMPLES
[All Samples - All Data]

TORRIDON HOUSE CAR PARK, WESTMINSTER

Date	December 2019
Prepared by:	mdh
Checked by:	
Revision:	00
Table	**1b**

Potential Contaminant		Measured Values			Upper Confidence Limit	Outlier Test		Critical Concentrations											
		Number of Tests	Minimum	Maximum		Critical Value	Number Exceedng	Residential w/produce		Exceeding No	Exceeding UCL	Residential w/o produce		Exceeding No	Exceeding UCL	Open Space residential		Exceeding No	Exceeding UCL
Petroleum Hydrocarbons																			
TPH aliphatic >C5-C6	mg/kg	12	<0.01	<0.01	-	-	0	42	(2)	0	-	42	(2)	0	-	570000	(2)	0	-
TPH aliphatic >C6-C8	mg/kg	12	<0.01	<0.01	-	-	0	100	(2)	0	-	100	(2)	0	-	600000	(2)	0	-
TPH aliphatic >C8-C10	mg/kg	12	<0.01	<0.01	-	-	0	27	(2)	0	-	27	(2)	0	-	13000	(2)	0	-
TPH aliphatic >C10-C12	mg/kg	12	<1.5	4.4	-	3.3	1	130	(2)	0	-	130	(2)	0	-	13000	(2)	0	-
TPH aliphatic >C12-C16	mg/kg	12	<1.2	24	-	11	1	1100	(2)	0	-	1100	(2)	0	-	13000	(2)	0	-
TPH aliphatic >C16-C21	mg/kg	12	<1.5	39	-	16	1	-		-	-	-		-	-	-		-	-
TPH aliphatic >C21-C35	mg/kg	12	<3.4	44	-	22	1	-		-	-	-		-	-	-		-	-
TPH aliphatic >C16-C35	mg/kg	12	<4.9	83	-	38	1	65000	(2)	0	-	65000	(2)	0	-	250000	(2)	0	-
Total TPH aliphatic >C5-C35	mg/kg	12	<10	110	-	57	1	-		-	-	-		-	-	-		-	-
TPH aromatic >C5-C7	mg/kg	12	<0.01	<0.01	-	-	0	70	(2)	0	-	370	(2)	0	-	56000	(2)	0	-
TPH aromatic >C7-C8	mg/kg	12	<0.01	<0.01	-	-	0	130	(2)	0	-	860	(2)	0	-	56000	(2)	0	-
TPH aromatic >C8-C10	mg/kg	12	<0.01	<0.01	-	-	0	34.0	(2)	0	-	47.0	(2)	0	-	5000.0	(2)	0	-
TPH aromatic >C10-C12	mg/kg	12	<0.90	1.4	-	1.2	1	74	(2)	0	-	250	(2)	0	-	5000	(2)	0	-
TPH aromatic >C12-C16	mg/kg	12	<0.50	29.0	2.1	17.0	1	140	(2)	0	-	1800.0	(2)	0	-	5100.0	(2)	0	-
TPH aromatic >C16-C21	mg/kg	12	<0.60	110.0	6.3	63.0	1	260	(2)	0	-	1900	(2)	0	-	3800	(2)	0	-
TPH aromatic >C21-C35	mg/kg	12	<1.4	190	20	142	1	1100	(2)	0	-	1900	(2)	0	-	3800	(2)	0	-
Total TPH aromatic >C5-C35	mg/kg	12	<10	330	33	215	1	-		-	-	-		-	-	-		-	-
Total EPH Aliphatic/Aromatic	mg/kg	12	<10	440	33	257	1	-		-	-	-		-	-	-		-	-
Hazard Index																			
Residential w/produce		12	0.03	0.88	0.06	0.54	1	-		0	-								
Residential w/o produce		12	0.02	0.24	0.02	0.15	1					-		0	-				
Open Space residential		12	0.00	0.09	0.01	0.06	1									-		0	-

Notes

(1) Denotes CL:AIRE C4SL for SOM of 1.0%

(2) Denotes CIEH S4ULs© for SOM of 1.0%

Full details of the assessment criteria are given in a guidance note included after the text of this report.

TPH Denotes Total Petroleum Hydrocarbons

X Denotes Upper Confidence Limit (UCL) exceeding assessment value

Hazard Index is the sum of the ratio of the measured concentrations to the assessment values for each carbon band.

Values below the Method Detection Limit taken to be 100% of the Method Detection Limit

Upper Confidence Limit is the concentration which the actual mean concentration will be below 19 times out of 20

Critical Value is the concentration above which values may be outliers of the data set. as determined using the Grubbs Test.

Upper Confidence Limits are determined excluding values exceeeding Critical Value

Upper Confidence Limits and Critical Values have been determined assuming the data forms a normally distributed dataset.

Potential Contaminant		Measured Values			Upper Confidence Limit	Outlier Test		Critical Concentrations							
		Number of Tests	Minimum	Maximum		Critical Value	Number Exceedng	Freshwater		Exceeding No	Exceeding UCL	Human Health		Exceeding No	Exceeding UCL
General Industrial Contaminants															
Arsenic	ug/l	5	0.29	2.6	2.2	4.5	0	50	(2)	0	-	10	(1)	0	-
Cadmium	ug/l	5	<0.02	0.04	0.03	0.04	0	0.08	(2)	0	-	5	(1)	0	-
Chromium (total)	ug/l	5	0.20	4.7	4.0	10.0	0	-		-	-	50	(1)	0	-
Copper	ug/l	5	2.3	6.5	6.1	8.5	0	1.0	(2)	5	**X**	2000	(1)	0	-
Lead	ug/l	5	<0.20	0.90	0.67	0.95	0	1.2	(2)	0	-	10	(1)	0	-
Mercury	ug/l	5	<0.05	<0.05	-	-	0	0.07	(2)	0	-	1.0	(1)	0	-
Nickel	ug/l	5	1.9	15.0	3.3	14.0	1	4.0	(2)	1	-	20	(1)	0	-
Selenium	ug/l	5	1.9	34	24	46	0	-		-	-	10	(1)	2	**X**
Zinc	ug/l	5	1.9	8.3	7.4	11.0	0	10.9	(2)	0	-	5000	(1)	0	-
Ammonium	ug/l	5	<15	620	417	832	0	-		-	-	500	(1)	1	-
Chloride	mg/l	5	37	250	235	469	0	-		-	-	250	(1)	0	-
Sulphate	mg/l	5	461	3020	2570	4420	0	-		-	-	250	(1)	5	**X**
BTEX	ug/l	5	<1.0	<1.0	-	-	0	-		-	-	-		-	-
TPH	ug/l	5	<10	<10	-	-	0	-		-	-	-		-	-
Total (of 16) PAHs	ug/l	5	<0.16	<0.16	-	-	0	-		-	-	-		-	-
Phenols	ug/l	5	<10	<10	-	-	0	7.7	(2)	5	-	500	(1)	0	-
pH	pH units	5	7.3	8.2	8.1	8.4	0	-		-	-	-		-	-
Total Alkalinity	mg/l	5	69	720	541	980	0	-		-	-	-		-	-
Electrical conductivity	µS/cm	5	1100	4800	4360	6800	0	-		-	-	-		-	-

Notes

(1) Assessment values for human health are taken from Statutory Instrument 2000 No.3184. The Water Supply (Water Quality) Regulations 2000

(2) Assessment values for Environmental Waters are taken from The Water Framework Directive (England and Wales) Directions 2015

Full details of the assessment criteria are given in a guidance note included after the text of this report.

BTEX Denotes Benzene, Toluene, Ethylbenzene and Xylene

TPH Denotes Total Petroleum Hydrocarbons (Aliphatics & Aromatics >C5-C35)

PAH Denotes Polynuclear Aromatic Hydrocarbons

X Denotes Upper Confidence Limit (UCL) exceeding assessment value

Values below the Method Detection Limit taken to be 100% of the Method Detection Limit

Upper Confidence Limit is the concentration which the actual mean concentration will be below 19 times out of 20

Critical Value is the concentration above which values may be outliers of the data set. as determined using the Grubbs Test.

Upper Confidence Limits are determined excluding values exceeeding Critical Value

Upper Confidence Limits and Critical Values have been determined assuming the data forms a normally distributed dataset.

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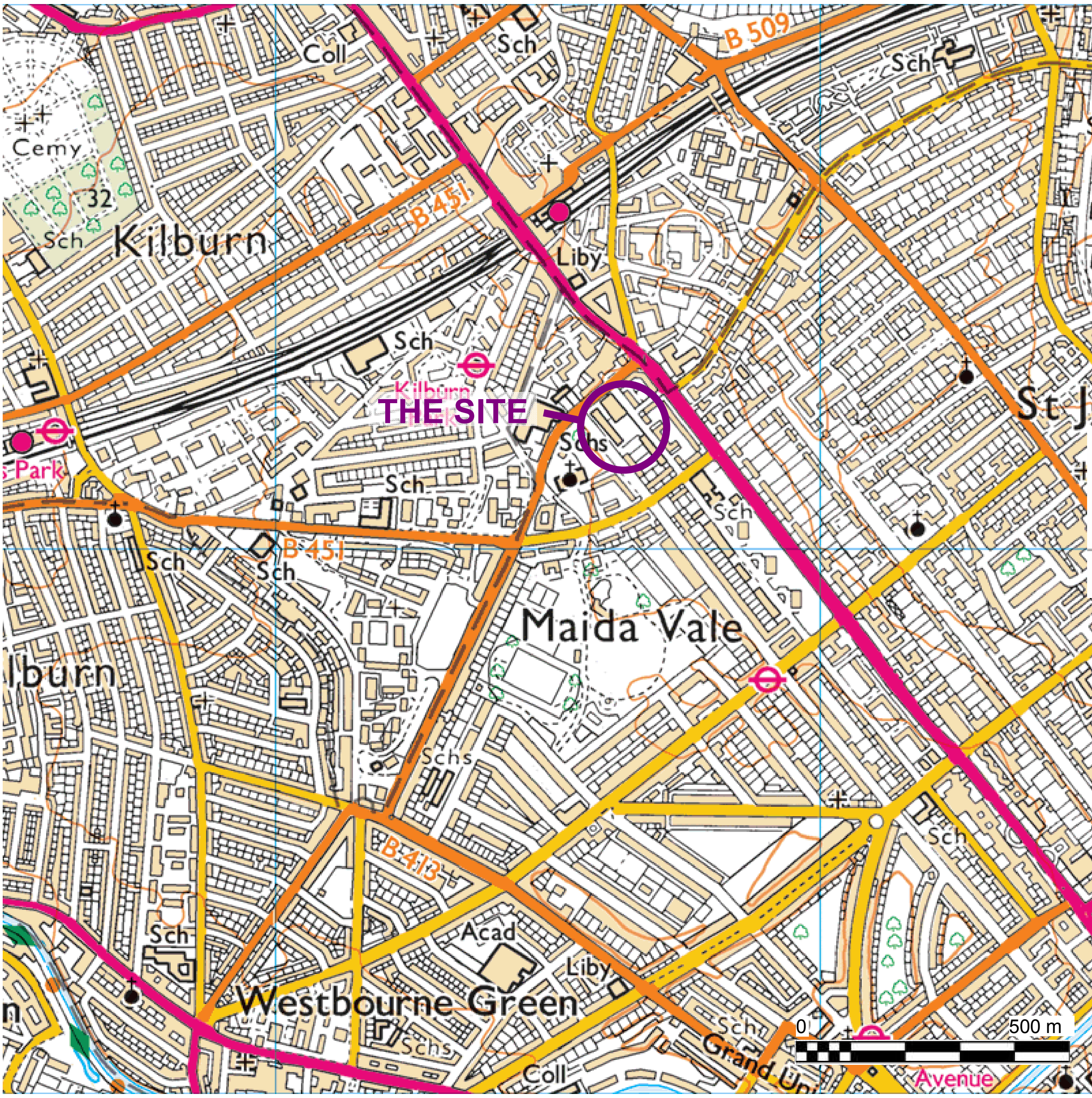
SUMMARY OF CHEMICAL ANALYSIS OF WATER SAMPLES
[All Samples - All Data]

TORRIDON HOUSE CAR PARK, WESTMINSTER

Date	December 2019
Prepared by:	mdh
Checked by:	
Revision:	00
Table	**2**

FIGURES



National Grid Reference	TQ 256 832
Coordinates	N51:32:02 W0:11:24
Nearest Post Code	NW6 5HR

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SITE LOCATION PLAN

TORRIDON HOUSE CAR PARK, WESTMINSTER

Date	Nov 2019
A4 Scale	1:12 500
Drawn	mdh
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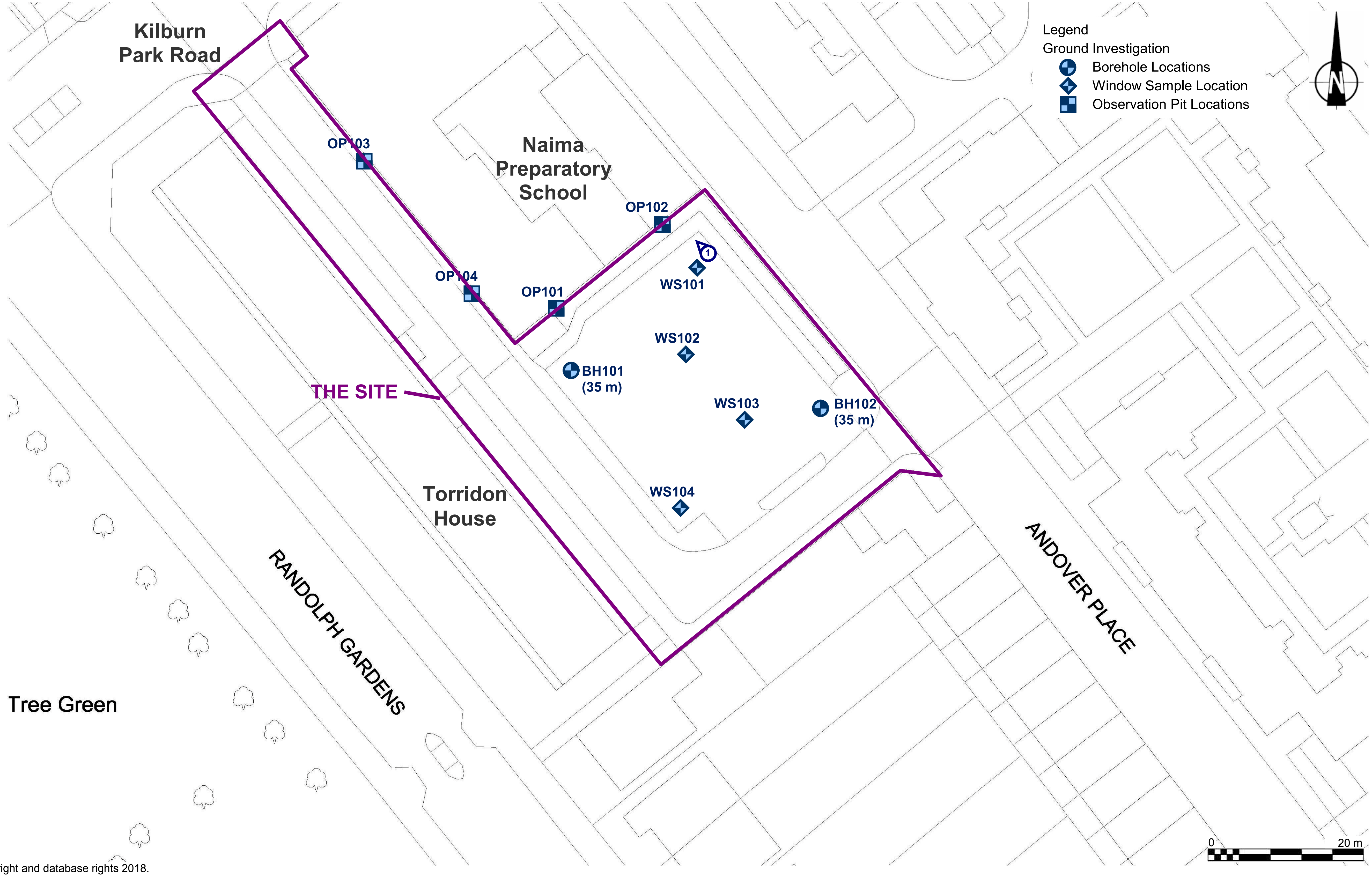
Figure	1



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SITE LAYOUT PLAN

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A3 Scale	approx 1:500
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Revision	03
Figure	2

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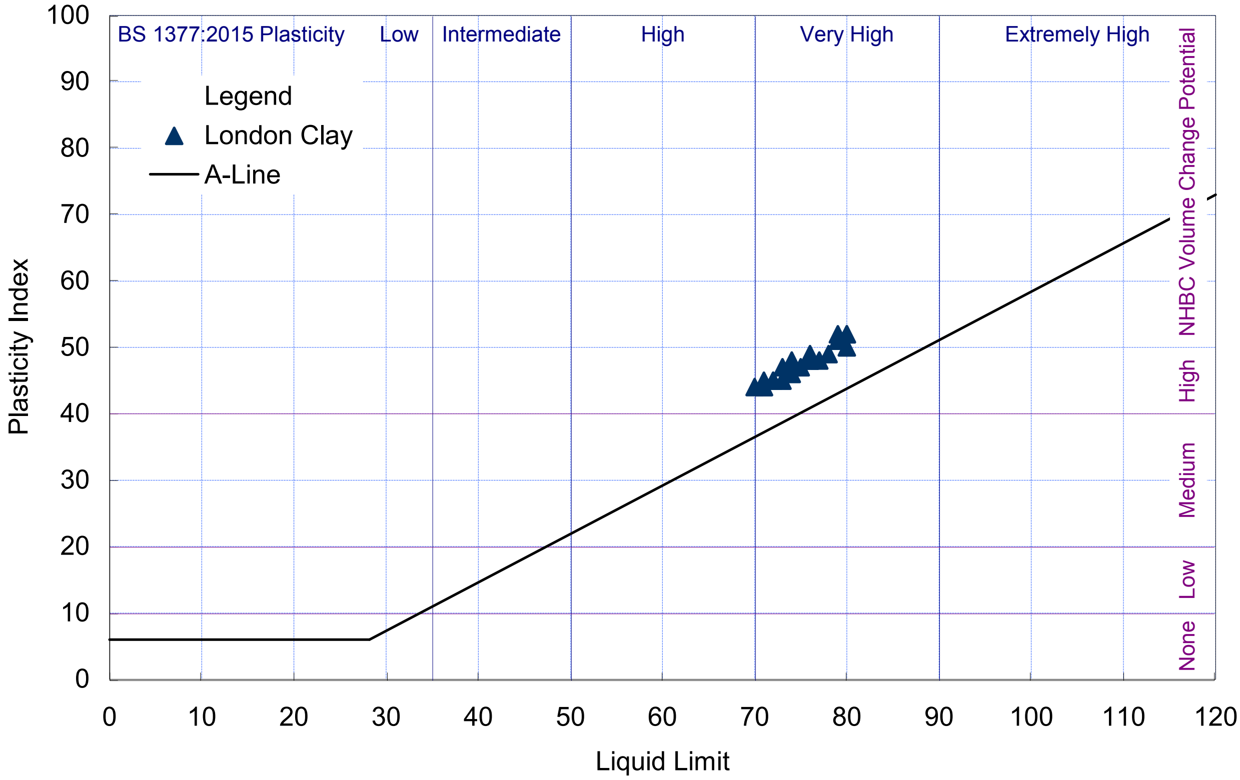

Notes

1 Values of liquid limit and plasticity index have not been modified by the percentage of particles less than 425μm.

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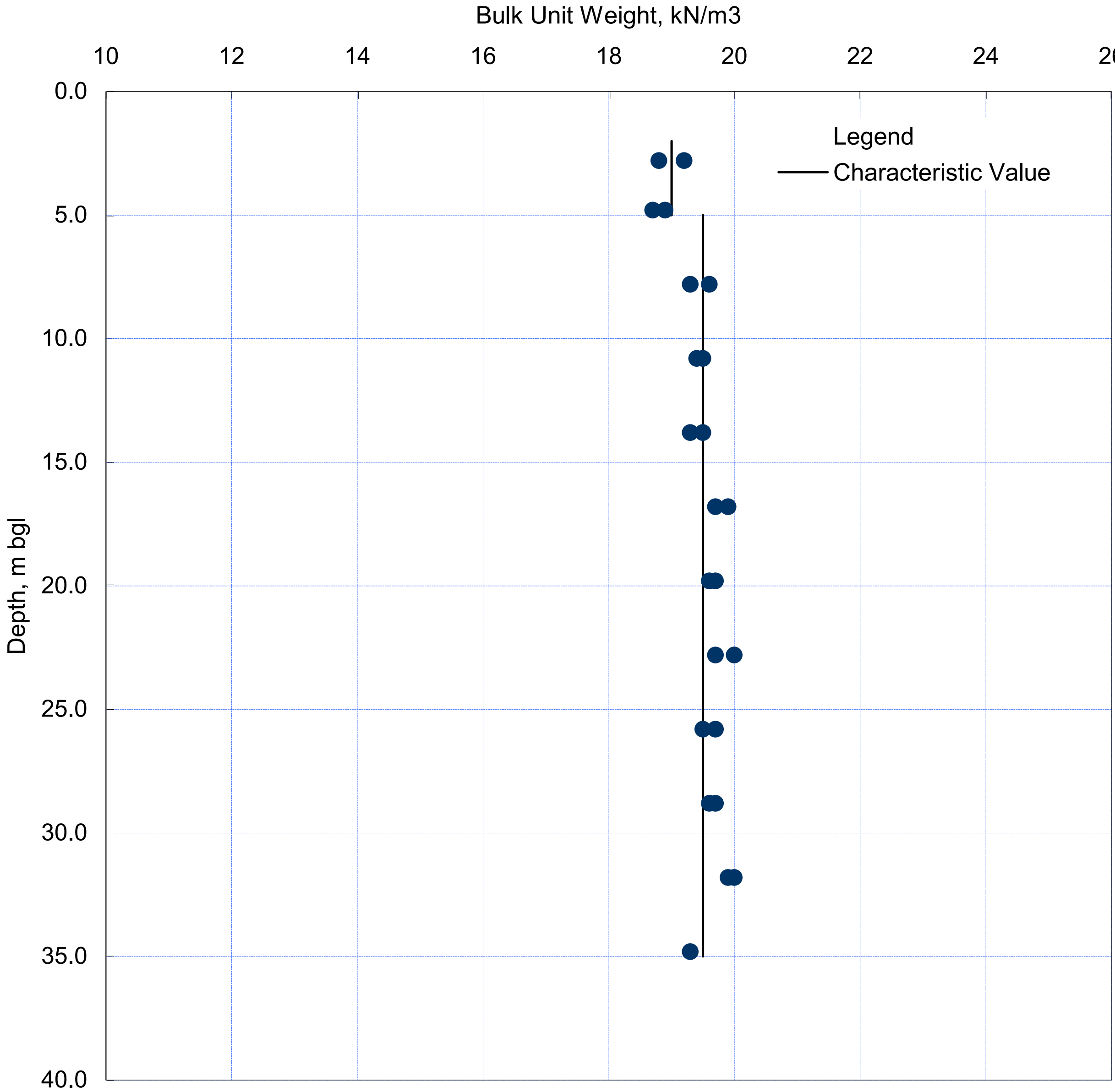
ATTERBERG LIMITS

TORRIDON HOUSE CAR PARK, WESTMINSTER

Date	November 2019
A4 Scale	nts
Prepared by	mdh
Checked by	
Revision	00
Figure	3



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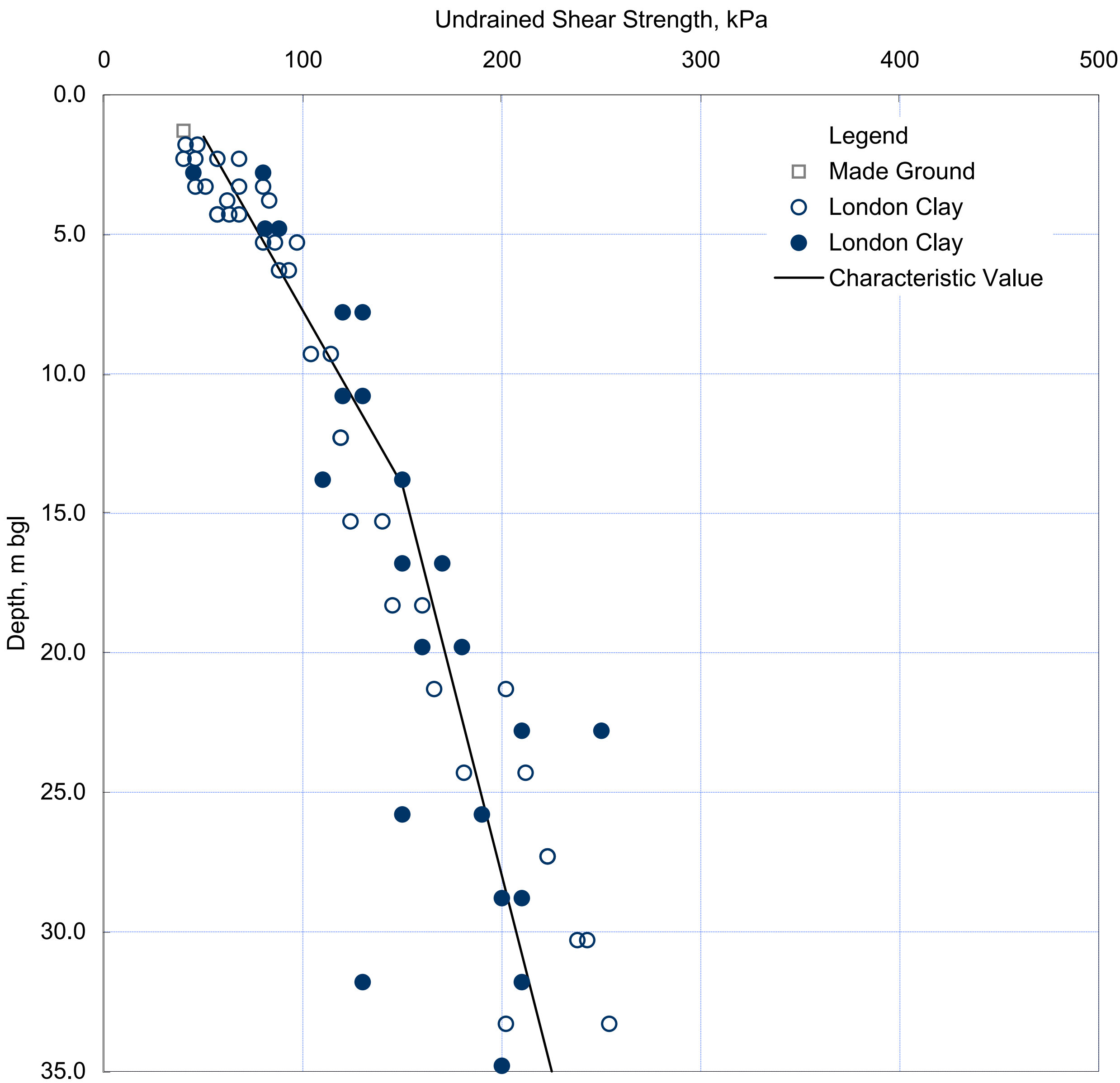

Notes

1 Open symbols denote values of undrained shear strength determined using the empirical correlation with SPT N values (Stroud, 1989) with a factor Nc of 4.5 and SPT N values normalised for hammer efficiency.

2 Closed symbols denote values of undrained shear strength determined by laboratory triaxial testing of 100 mm diameter specimens

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peterbrett.com	City of Westminster	UNDRAINED SHEAR STRENGTH	A4 Scale	nts
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Tel: 01189 500 761			Revision	00
			Figure	5